SPIFI Operation Manual 2004

for AST/RO Winterovers

BY

THOMAS OBERST

STEPHEN PARSHLEY

THOMAS NIKOLA

& GORDON STACEY

Table of Contents

List of Tables

List of Figures

INTRODUCTION: IMPORTANT BASICS

Contact Information

You will be able to find a good deal of the information you will need for day-to-day operations of SPIFI in this manual. However, when questions arise, don't hesitate to contact one of the members of the SPIFI team:

Thomas Nikola
Cornell University
224 Space Sciences Bldg.
Ithaca, NY 14853
Email: tn46@cornell.edu
Office Phone: 607-255-3140

Steve Parshley
Cornell University
226 Space Sciences Bldg.
Ithaca, NY 14853
Email: scp8@cornell.edu
Office Phone: 607-255-4806
Cell Phone: 413-219-6305

Thomas Oberst
Cornell University
226 Space Sciences Bldg.
Ithaca, NY 14853
Email: teo4@cornell.edu
Office Phone: 607-255-4806
Cell Phone: 607-731-0577

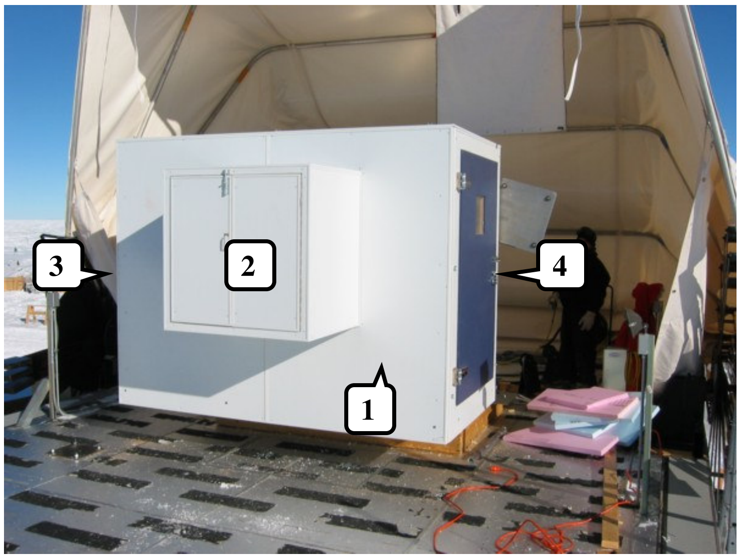
Gordon Stacey
Cornell University
212 Space Sciences Bldg.
Ithaca, NY 14853
Email: stacey@astro.cornell.edu
Office Phone: 607-255-5900
Home Phone: 607-273-9380

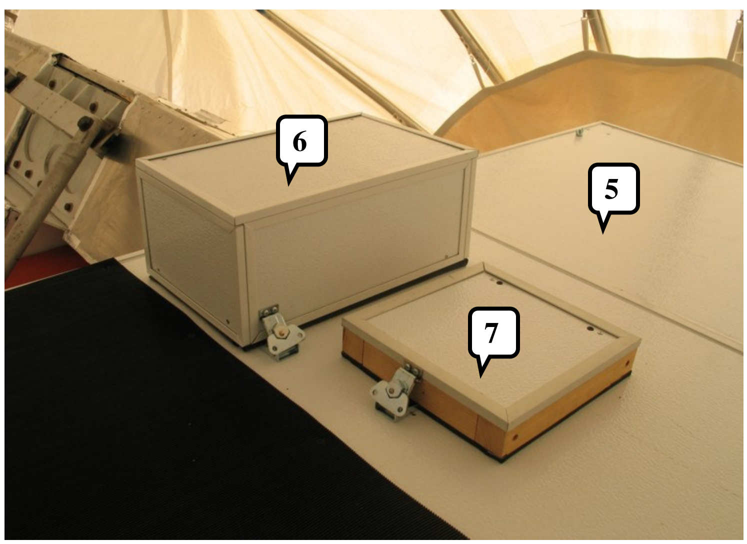
Figure 1: "The Gang" at the Ceremonial Pole

SPIFI Quick Locator Guide

Images of SPIFI and of most of our operating equipment are shown below with labels indicating what's what. This is intended as a quick guide for understanding the SPIFI setup and for locating equipment discussed in this operation manual. **Throughout the rest of this manual, bold numbers in parenthesis will refer to numbered pictures in this *Quick Locator Guide*.**

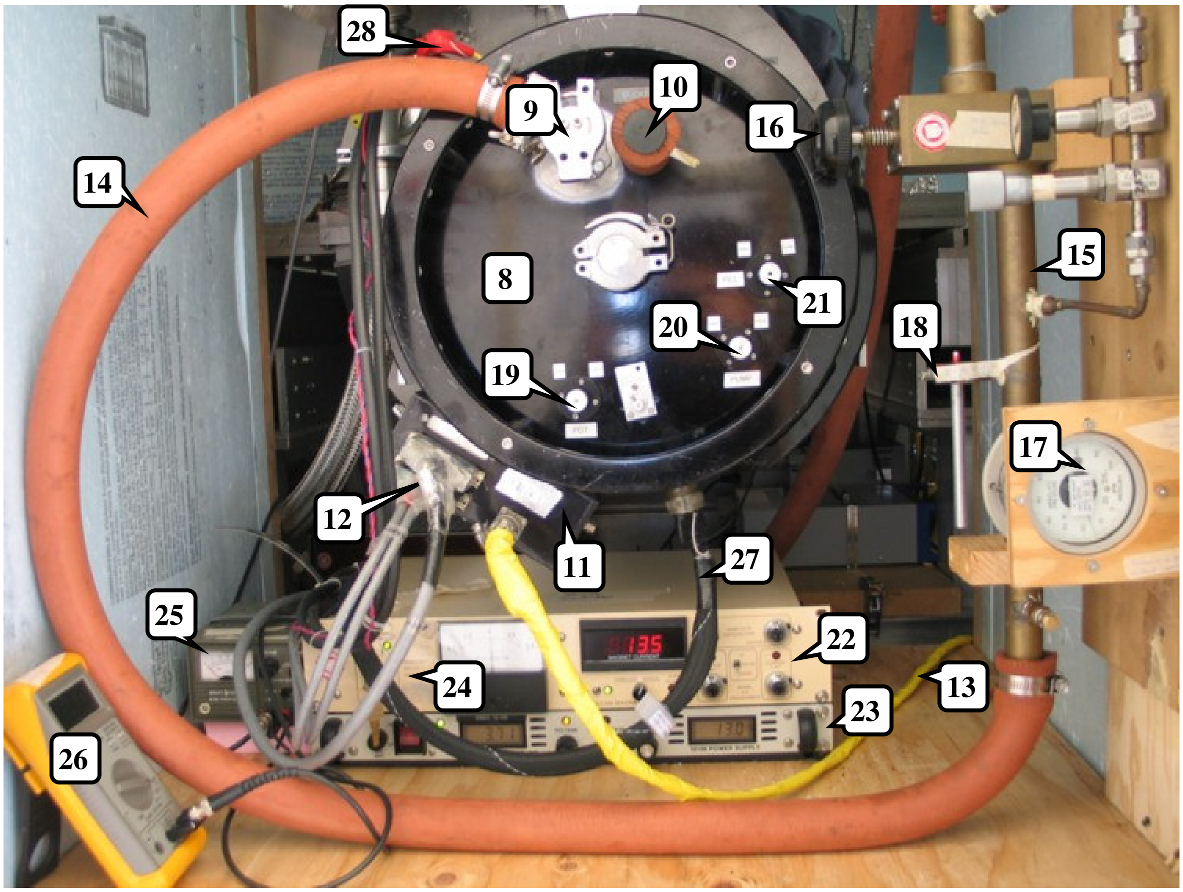
The SPIFI enclosure





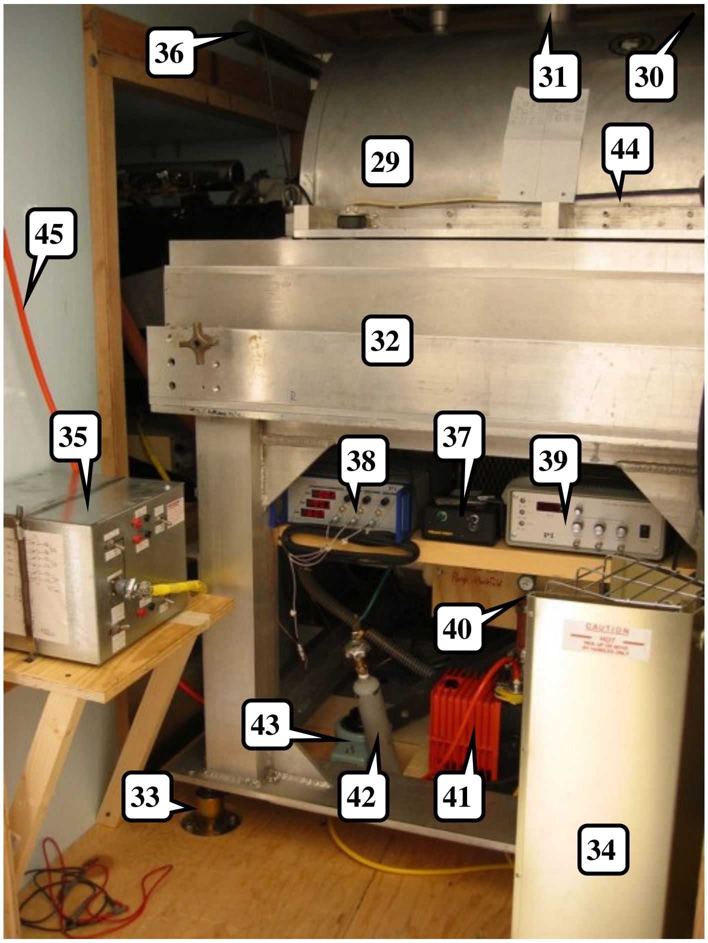
1. The SPIFI enclosure
2. The "pillbox"
3. Right side (or "Fabry" side) of enclosure
4. Left side (or "battery box" side) of enclosure
5. Roof of enclosure
6. Hatch for SPIFI l-N_2 neck
7. Hatch for SPIFI l-^{4}He neck

Inside the Pillbox



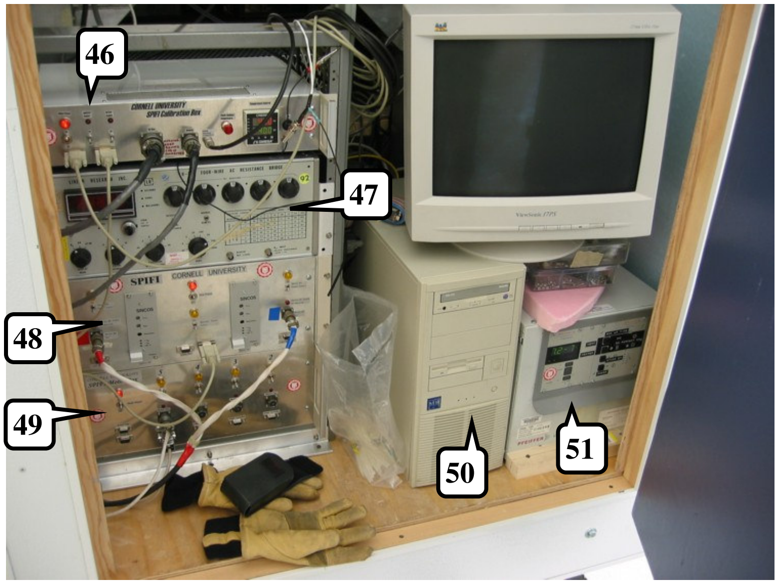
8. ADR outer shell
9. ADR l-^{4}He neck (connected to pump via KF end-cap and clamp assembly)
10. ADR l-N_2 (“stickstoff”) neck
11. Preamplifier box
12. Data cables (from pre-amp to Fabry)
13. Pre-amp power supply cable (from battery box)
14. Vacuum hose for pumping on ADR l-^{4}He tank
15. ADR l-^{4}He tank pump manifold
16. Main pump valve for the ADR l-^{4}He tank
17. Pressure gauge for ADR l-^{4}He tank
18. ^{4}He “Gas inlet” (or “Backfill”) valve for l-^{4}He tank
19. ^{3}He pot heat switch
20. ^{3}He pump heat switch
21. Salt pill heat switch
22. Magnet control box
23. Magnet power supply box
24. Persistent switch switch (yes, the switch has a switch)
25. Power supply for charcoal heater (also called the ^{3}He pump heater)
26. Ohmmeter for monitoring temperature of ^{3}He pump
27. Housekeeping cable
28. Magnet leads

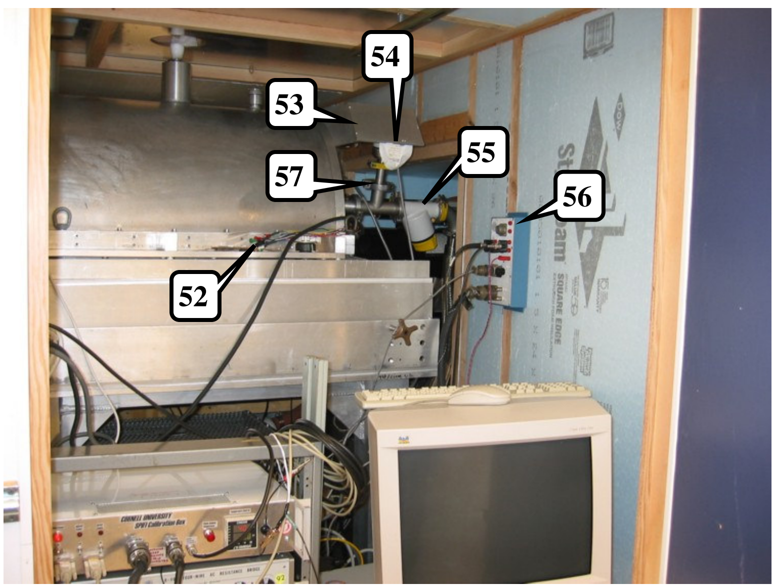
Inside the left side door of the enclosure



29. SPIFI outer shell
30. SPIFI l-N_2 neck
31. SPIFI l-^4He neck
32. SPIFI alignment table
33. Dampers
34. Enclosure heater
35. Battery box
36. "Laser" (must be pronounced as by Dr. Evil of Austin Powers).
37. "Laser" power
38. HOFPI PZT power supply (PI power supply)
39. LOFPI PZT power supply (PI power supply)
40. Gas cell manifold
41. Gas cell pump
42. Gas lecture bottle
43. Variac voltage regulator (not currently in use)
44. Steve's special ***hand-carved*** dipper stick
45. Gas cell pump exhaust

Inside the right side door of the enclosure





46. Electronic control box for the calibration unit
47. Resistance bridge for monitoring GRT temperatures
48. HOFPI and LOFPI stepper motor box
49. SPIFI motor box
50. Fabry
51. Turbo pump
52. resistor leads for SPIFI temperature monitoring
53. “laser” mirror mount
54. screen for viewing fringes
55. main SPIFI pump valve
56. The blue box on the wall (“blue switch board” or “blue connector box”)
57. Pressure gauge for monitoring pressure inside SPIFI (displayed on front of turbo pump)

Catastrophic Mistakes To Avoid

In no particular order, here are catastrophic mistakes that must be avoided. You should remind yourself of these caveats regularly to the point that they become part of your everyday thinking process while operating SPIFI. This is not a troubleshooting guide: if you have trouble with one of the things listed in this table then it is probably already too late.

Mistake	**Undesirable Result**	**How To Avoid**	**Where To Find More Info**
Loosing track of the HOFPI or LOFPI position	• You could crash the Fabry-Perot plates and incapacitate SPIFI. • You could loose all knowledge of what order the HOFPI and LOFPI are in, which will make the spectra meaningless • Our summer calibration efforts are wasted.	• When starting a new SPIFI session, make sure to properly initialize the HOFPI and LOFPI to the last positions they were in. Although the indexer should remember (if it wasn't turned off), refer to your written notes to make sure. • After restarting Fabry **(50)**, you will have to re-initialize the HOFPI and LOFPI to the last position they were in. Although the indexer should remember, refer to your written notes to be sure. • After turning on the cryo-motor box **(48)** from being off, you will have to initialize the HOFPI and LOFPI to the last positions they were in (here the indexer will not remember the values, but will use 0. You will have to use your written notes to correct this). • Keep careful notes of every scan done and of how many counts either the LOFPI or HOFPI were moved, and in which direction. • Before starting every scan, make sure you have reset the LOFPI and/or HOFPI to the desired starting values (including backlash correction) in the Matlab environment, *and* make sure you have entered these starting values in the scan GUI. • Double check both your written notes as well as the values you type into the computer to avoid typos and transcription errors.	SPIFI Data Acquisition Manual
Forgetting to disconnect the PZT cables before turning on the high-voltage PZT power supplies **(38)** & **(39)**	You could destroy the PZT's because of a large startup current (voltage)	• Always disconnect the PZT cables from channels 1, 2, & 3 whenever you turn off the high-voltage power supplies. • Always turn the power to PZT channels 1, 2, and 3 down all the way before turning on the power supply (and before hooking up the PZT leads).	Page 53
Turning up the voltage on any of the PZT's to more than 700V	You could destroy the PZT's	• Always adjust the PZT voltages slowly and keep an eye on the nominal values, don't just stare at the fringes. Never exceed 700V in any of the channels 1, 2, or 3. • Always turn the power in channels 1, 2, and 3 to zero before turning on the PZT power supply	Page 53

Mistake	Undesirable Result	How To Avoid	Where To Find More Info
Allowing the SPIFI enclosure to freeze inside (go below 0°C)	• Fabry won't function properly • Fans may be destroyed inside Fabry, the magnet control boxes, and other electronics boxes • Other electronic components may fail • The O-rings in SPIFI may fail and we'll loose our vacuum.	• Check the temperature (by feel or by thermometer) of the enclosure at the beginning and end of every day. • Make sure both heaters are working. If one fails, replace it immediately. • Try not to open the enclosure doors for very long • Keep the doors shut as far as possible behind you when working in the enclosure • Always shut the doors and latch them whenever you are done.	Page 19
Opening the main yellow valve **(55)** between SPIFI and the turbo pump if SPIFI is under vacuum and/or the pump is turned off.	SPIFI may loose pressure through the turbo pump.	• Remember to close the valve when you have finished pumping SPIFI down. • Remember to close the valve if there will be a power outage and you are still pumping on SPIFI. • Never open the valve to the atmosphere if SPIFI is still under vacuum.	Page 20
Opening SPIFI to the atmosphere in any way while at low pressures	The Fabry-Perots will blow out.	• Be extremely careful when working near any windows on SPIFI. Do not puncture these windows • Don't let the enclosure freeze, as this will freeze the o-rings and cause them to fail. • Never open the yellow valve (**55**) if the other side is at atmospheric pressure	Page 20
Moving SPIFI within the enclosure	We loose our alignment to the telescope and our offset calculations	• Don't use the SPIFI alignment table (**32**) to pull yourself up into the enclosure. • Try not to bump or push SPIFI or the ADR.	
Over-pressurizing the calibration gas cell	• You will blow out the windows to the gas cell • You will have to jury-rig some type of new blackbody and calibration source, since gas cell and blackbody are inaccessible for maintenance.	• Fill the gas cell very slowly, and monitor the pressure meter carefully while doing so • Keep the bleeder valve near the lecture bottle closed, and open the main valve for only a second or two (we call this "one shot"). Close the main valve, and then very carefully open the bleeder valve to fill the gas cell. Monitor the pressure gauge carefully. We typically use about 50 - 150 Torr. • If you hear any popping noises, shut off the gas flow immediately. This is the sound of the gas cell windows bulging.	Page 49

Mistake	**Undesirable Result**	**How To Avoid**	**Where To Find More Info**
Charging the battery box **(35)** incorrectly	You could ruin the batteries in Box #1. Box #2 already has at least one bad battery. Therefore there is no immediate backup if Box #1 is damaged. (However, in an emergency you could use whichever batteries are still good from Box #2 and you could also take batteries from the "old" battery box which is in the SPIFI crate labeled "A2" in the AST/RO Annex.	• Read all the labels and warnings on the front of the battery box before hooking it up to the chargers • The normal charging configuration is to have the two left-hand switches on the battery box all the way down (they are 3-position switches), and the two right-hand switches all the way up. You then connect one blue 12V charger to 12V battery #1 (red-to-red, black-to-black), and the other blue 12V charger to 12V battery #2 (red-to-red, black-to-black). (Make sure you connect the charging cables to the battery box *before* plugging in the chargers to avoid the risk of electrical shock. The chargers have no on/off button, and the charging leads become live as soon as the charger is plugged in. Also, by the same token, when charging is complete, unplug the chargers before removing the charging cables). • The switches on the blue power supplies should be at "Normal/Automotive", "Charge", and "2A-12V Auto." There is no power button: you start the charging by plugging the charger into 120AC. • Switch 3 is very important. If switch 3 is up, then the + terminal of one of the 12V batteries is connected to the – terminal of the second 12V battery. This is a special situation that allows you to charge while observing at the same time. The charging and switch configuration in this case is non-trivial. Refer to the circuit diagram of the battery box, the instructions in this manual, or contact us if you need to.	Page 57
Overfilling l-N_2 into the SPIFI and ADR l-^{4}He tanks during an initial cool-down	• You might not be able to get the l-N_2 out of the tanks • If you are able to get the l-N_2 out using the special blow-out devices, you will unnecessarily waste some l-N_2 in the process	Follow the cool-down filling instructions carefully and keep an eye on the temperature.	Page 22

Mistake	**Undesirable Result**	**How To Avoid**	**Where To Find More Info**
Filling l-N_2 or l-^{4}He too fast (at too high of a pressure) during an initial cool-down from room temperature	You may get an overpressure inside SPIFI's and the ADR's cryogen tanks which could open up leaks or cause an explosion.	Fill the cryogen tanks on SPIFI and the ADR slowly (~1-1.5 psi in the fill Dewar) during an initial cool-down to allow time for boil-off gas to escape out of the fill necks.	Page 23
Closing the main brass pump valve on the SPIFI l-N_2 neck **(30)** while l-N_2 is in SPIFI's tank.	You may get an overpressure inside SPIFI's l-N_2 tank which could open up leaks or cause an explosion.	If you must keep the main pump valve closed for an extended period of time (more than 2-3 hours, for instance in the case of an extended power outage), you should backfill with N_2 gas and open the tank to the atmosphere (see step 2 on page 62).	Pages 34, 14 & 16, and 62
Closing the main pump valve on the ADR l-^{4}He pump manifold **(16)** while l-^{4}He is in the ADR's tank.	You may get an overpressure inside the ADR's l-^{4}He tank which could open up leaks or cause an explosion.	• Monitor the pressure gauge **(17)** on the ADR l-^{4}He manifold to make sure that the pressure does not start climbing. If the pressure climbs steadily up to 100 Torr (which is the maximum value on the gauge) and beyond, there is most likely significant boil-off and you should either start pumping again or backfill with ^{4}He gas and open the ADR's l-^{4}He tank to the atmosphere. • There is a pressure release valve on the ADR l-^{4}He pump manifold which might be able to handle the job. • However, if you must keep the main pump valve closed for an extended period of time (more than 2-3 hours, for instance in the case of an extended power outage), you should backfill with ^{4}He gas and open the tank to the atmosphere (see steps 1-6 of *ADR Helium* on page 35).	Page 35, 14 & 16
Opening the second green Swagelok valve further back on the top of the ADR (see Figure 5 on page 26 below)	• All of our precious ^{3}He gas will be released from the ^{3}He fridge into the atmosphere • A couple thousand dollars will float away • The instrument will be useless	Don't touch this valve ever!	Pages 25 & 26

Emergency Shutdown Checklists

Outlined below are checklists for shutting down SPIFI in the case of an announced (case 1) or unannounced (case 2) power outage. The information in these lists has been kept as brief as possible so that they can be used quickly in the case of an emergency. Much more detailed information about all of the procedures involved in shutting SPIFI down and powering SPIFI back up is provided in other parts of this manual. We covered everything we could think of here, but in practice new situations always arise which have not been dealt with before. It is therefore very important to think about what you are actually doing to SPIFI while going through these checklists, and there may be times when you will have to deviate from the lists below to handle whatever circumstances or obstacles arise. Understanding how SPIFI works comes with time and experience, but having read through this manual ahead of time (before an emergency outage occurs) will certainly help.

Case 1: You have been notified that there will be a power outage, and the power is currently still on

☐ 1. Secure the ADR **(8)**, including the magnet power supply **(23)** and magnet control box **(22)**:

Case I. If time allows, you should always try to have the ADR completely cycled and cold (i.e. 60mK) before the power outage. In this case you don't need to do anything. The magnet control box **(22),** and the magnet power supply **(23)** should already be turned off in this case. If they aren't, turn them off.

Case II. If the ADR needs to be cycled and there is not time to complete a full cycle before the power outage, then you have two options:
(a) Wait until the power comes back on to start the cycle, or…
(b) If you have 45 minutes to an hour until the power outage, get the first half of the cycle done (up to step 21 of *Step-By-Step Cycling of the ADR and 3He Fridge* on page 45 below). Make sure you turn off the charcoal heater **(25)** right before the power goes out (this is not part of the cycling procedure). The magnet control box **(22),** and the magnet power supply **(23)** should be turned off by the time of the outage.

Case III. If the ADR is in the process of being cycled and you don't have time to finish the cycle before the power outage, then:
(a) If you are in the first stages of cycling and you have enough time, get the first half of the cycle done (up to step 21 of *Step-By-Step Cycling of the ADR and 3He Fridge* on page 45 below). Make sure you turn off the charcoal heater **(25)** right before the power goes out (this is not part of the cycling procedure). The magnet control box **(22),** and the magnet power supply **(23)** should be turned off by the time of the outage.
(b) **If you don't have much time, the most important thing to do is make sure there is no current in the magnet leads when the power goes out**. If there is any current in the leads, power may be dumped into the solenoid when the power goes out and the whole system will heat up and boil-off cryogens.

- ☐ Set the current ramp rate on the magnet controller **(22)**. If you are demagnetizing the solenoid (i.e. if the persistent switch heater **(24)** is turned on), then 0.1 amps/sec is ideal, but this takes ½ hour or so. If you don't have ½ hour then 1 amp/sec is better than nothing. If you are not demagnetizing the solenoid (i.e. if the persistent switch heater is turned off) then you can ramp down at 10 amps/sec.
- ☐ Flip the current ramp direction on the magnet controller to the down position.
- ☐ Wait until the magnet controller reads 0.00 amps (or 0.01 amps)
- ☐ Turn off the persistent switch heater **(24)** (if it was ever on)
- ☐ Turn off the magnet control box **(22)** and the magnet power supply **(23)** at the same time

- □ Also make sure the charcoal heater **(25)** is turned off.

□ 2. Secure the PZT's:

<u>HOFPI</u>

- □ Turn the PZT voltages all the way down (fully counterclockwise) on the PI power supply **(38)**. Make sure channels 1, 2, and 3 are all at 0V.
- □ Diconnect all three PZT cables (A, B, & C) from the PI power supply and cap them with the resistor caps which should be on top of the PI power supply.
- □ Turn off the PI power supply.

<u>LOFPI</u> (If applicable: We did not need to use the LOFPI PZT's over the Antarctic summer)

- □ Turn the PZT voltages all the way down (fully counterclockwise) on the PI power supply **(39)**. Make sure channels 1, 2, and 3 are all at 0V.
- □ Diconnect all three PZT cables (A, B, & C) from the PI power supply and cap them with the resistor caps which should be on top of the PI power supply.
- □ Turn off the PI power supply.

□ 3. Properly shutdown Fabry **(50)**:

- □ Turn on the monitor inside the right side door of the enclosure
- □ At the prompt, type the following sequence of commands (">" means type at the prompt, "␣" means hit the space bar once, and "↵" means strike the enter key):
  - > root ↵
  - > whoami ↵

  This last command, "whoami", will tell you what kind of user you are. If you are the "root" user, continue. If you are not "root", type > su ↵ and enter the password > r = fin*ord ↵ to become the super user. Then continue:

  - > cd ␣ / ↵
  - > shutdown ␣ -h ␣ now ↵
- □ Wait for Fabry to go through its shutdown procedure.
- □ When the screen indicates that everything has been halted, go ahead and push the power buttons on the Fabry PC and on the monitor.

□ 4. Secure the pumps:

- □ If SPIFI is on the pump you will need to first close the main pump valve **(55)** and then turn off the turbo pump **(51)**. The main pump valve is the big yellow valve to the top-left of the SPIFI/ADR interface. It is spring-loaded and can only be turned to either "open" or "closed".
- □ If the ADR l-^{4}He tank is on the pump, close the main pump valve **(16)** on the ADR pump manifold **(15)** and turn off the corresponding "pumpzilla" in the receiver room by flipping the switch on the breaker box on the wall.
  ***Warning**: After closing the pump valve, the ADR l-^{4}He tank will be a closed system, and boil-off could create an over-pressure. If the pressure gauge **(17)** maxes out (i.e. the pressure rises over 100 Torr) then you should backfill with ^{4}He gas and then open the tank to the atmosphere (see steps 1-6 of ADR Helium on page 35). You probably also need to refill at this point, since a high pressure indicates lots of boil-off.*
- □ If SPIFI's l-N_2 tank is on the pump, close the brass valve on the SPIFI l-N_2 neck **(29)** and turn off the corresponding "pumpzilla" in the receiver room by flipping the switch on the breaker box on the wall.

***Warning**: After closing the pump valve, the SPIFI l-N_2 tank will be a closed system, and boil-off could create an over-pressure. If the power outage lasts more than 2-3 hours then you should backfill with N_2 gas and then open the tank to the atmosphere (see step 2 on page 62).*

- □ If you have been using the gas cell, make sure the gas cell pump **(41)** is unplugged (there is no on/off button on this pump).

□ 5. Shut down all other electronic devices:

- □ Calibration control box **(46)**: in the following order (and from right to left), turn off the temperature control unit, turn off the driver, turn off the indexer, turn off the main power switch.
- □ Turn off the resistance bridge box **(47)**.
- □ Cryo-motor box **(48)**: in the following order, turn off both the HOFPI and LOFPI driver power, turn off the indexers' power, and turn off the main power.
- □ SPIFI motor box **(49)**: in the following order, turn off switch "5," and then turn off the main power.
- □ Make sure the "laser" power is turned off **(37)**.
- □ Turn off the battery box **(35)** by pushing Switch #1 on the battery box down.
- □ Turn off the preamp **(11)** by moving the two left-most switches to "off" and "bat" (both switches up).

□ 6. Don't let the cryogen tanks run dry during the power outage!

Case 2: The power went out unexpectedly

□ 1. Secure the ADR **(8)**, including the magnet power supply **(23)** and magnet control box **(22)**:

- □ Make sure the persistence switch heater **(24)** on the magnet control box **(22)** is turned to the "off" position (key should be vertical).
- □ Make sure the current ramp rate switch on the magnet control box is flipped to "down".
- □ Make sure the main power switches on the magnet control box and the magnet power supply are switched to their "off" positions.
- □ Make sure the charcoal heater **(25)** is turned off.

□ 2. Secure the PZT's:

<u>HOFPI</u>

- □ Turn the PZT voltage knobs all the way down (fully counterclockwise) on the PI power supply **(38)**. Make sure channels 1, 2, and 3 are all turned to 0V.
- □ Move the power switch of the PI power supply to the "off" position.
- □ Disconnect all three PZT cables (A, B, & C) from the PI power supply and cap them with the resistor caps which should be on top of the PI power supply.

<u>LOFPI</u> (If applicable: We did not need to use the LOFPI PZT's over the Antarctic summer)

- □ Turn the PZT voltages all the way down (fully counterclockwise) on the PI power supply **(39)**. Make sure channels 1, 2, and 3 are all turned to 0V.
- □ Move the power switch of the PI power supply to the "off" position.
- □ Disconnect all three PZT cables (A, B, & C) from the PI power supply and cap them with the resistor caps which should be on top of the PI power supply.

□ 3. Unplug Fabry **(50)**. This will prevent Fabry from booting up automatically when the power comes back on. (Pressing the power switch of Fabry when the power is out does not turn the machine off, probably because the switch is on a relay which needs electrical power to change its position.)

□ 4. Secure the pumps:

- □ If SPIFI is on the pump you will need to close the main pump valve **(55)** and also push the power button on the Turbo pump **(51)** once so that it is in the "off" setting and does not start up automatically when the power comes back on. The main pump valve is the big yellow valve to the top-left of the SPIFI/ADR interface. It is spring loaded and can only be turned to either "open" or "closed".
- □ If the ADR l-^{4}He tank is on the pump, close the main pump valve **(16)** on the ADR pump manifold **(15)** and turn off the corresponding "pumpzilla" in the receiver room by throwing the switch on the breaker box on the wall.
  Warning**:** *After closing the pump valve, the ADR l-^{4}He tank will be a closed system, and boil-off could create an over-pressure. If the pressure gauge* ***(17)*** *maxes out (i.e. the pressure rises over 100 Torr) then you should backfill with ^{4}He gas and then open the tank to the atmosphere (see steps 1-6 of ADR Helium on page 35). You probably also need to refill at this point, since a high pressure indicates lots of boil-off.*
- □ If SPIFI's l-N_2 tank is on the pump, close the brass valve on the SPIFI l-N_2 neck **(29)** and turn off the corresponding "pumpzilla" in the receiver room by throwing the switch on the breaker box on the wall.
  Warning**:** *After closing the pump valve, the SPIFI l-N_2 tank will be a closed system, and boil-off could create an over-pressure. If the power outage lasts more than 2-3 hours then you should backfill with N_2 gas and then open the tank to the atmosphere (see step 2 on page 62).*
- □ If you have been using the gas cell, make sure the gas cell pump **(41)** is unplugged (there is no on/off button on this pump).

□ 5. Flip "off" the power switches on all other electronic devices:

- □ Calibration control box (**46**): turn off the temperature control unit, turn off the driver, turn off the indexer, and turn off the main power switch.
- □ Turn off the resistance bridge box (**47**).
- □ Cryo-motor box (**48**): turn off both the HOFPI and LOFPI driver power, turn off the indexers' power, and turn off the main power.
- □ SPIFI motor box (**49**): turn off switch "5" and turn off the main power.
- □ Make sure the "laser" power is turned off (**37**).
- □ Turn off the battery box **(35)** by pushing Switch #1 on the battery box down.
- □ Turn off the preamp **(11)** by moving the two left-most switches to "off" and "bat" (both switches up).

□ 6. Don't let the cryogen tanks run dry during the power outage!

Power-Up Checklist (After an Emergency Shutdown)

 1. If SPIFI was on the turbo pump **(51)** before the power went out, then:
    - □ Restart the turbo pump
    - □ Ideally you want to have the same pressure on both sides of the main pump valve **(55)** (This is the big yellow valve to the top-left of the SPIFI/ADR interface) before opening it. There is no pressure gauge on the vacuum hoses between the main pump valve and the turbo pump, so use your best estimate of how long to let the turbo pump run to achieve an equilibrium between the pressure in SPIFI and the pressure in the vacuum hose. (The pressure in SPIFI is always the pressure shown on the front of the turbo pump).
    - □ Open the main pump valve. It is spring loaded and can only be turned to either "open" or "closed".

 2. Assuming that you didn't let the cryogen tanks run dry and they don't need filled, then you can recommence pumping on the ADR l-^{4}He tank and the SPIFI l-N_2 tanks:
    - □ Turn on the two "pumpzillas" in the receiver room and wait several minutes for the vacuum hoses to get pumped out.
    - □ *Slowly* open the main pump valve on the ADR l-^{4}He pump manifold **(16)** to start pumping on the ADR l-^{4}He tank. You should spend at least 5 minutes cracking this valve to minimize stress on the pump.
    - □ *Slowly* open the brass valve on the SPIFI l-N_2 neck to start pumping on the SPIFI l-N_2 tank. You should spend at least 5 minutes cracking this valve to minimize stress on the pump.

 3. Check the temperature of the ADR (refer to *ADR Temperature Check* on page 30 below if you don't know how to do this).

 4. Cycle the ADR:

Case I. If cycling of the ADR was already complete when the power went out and you are still within the limits of the hold time (40 hours normally), then you might still be cold. Keep in mind, however, that the remainder of the hold time will be shortened if the pumps where turned off, since the temperature in the ADR's l-^{4}He tank and in SPIFI's l-N_2 tank will have risen.

Case II. If you are powering back up from the four hour waiting period of the cycling process (step 21 of *Step-By-Step Cycling of the ADR and 3He Fridge* on page 45 below), then you can pick up the waiting process where you left off:

- □ Make sure that the ^{3}He fridge is still set up properly: the pump heat switch **(20)** should be open, the pot heat switch **(19)** should be closed, the pill heat switch **(21)** should be closed, and the housekeeping cable **(27)** should be plugged into the ADR.
- □ Turn on the charcoal heater **(25)** and set it to 5 volts.
- □ Check that the resistance (of the ^{3}He pump) is going down on the multimeter **(26)** which is connected to the ^{3}He pump heater.
- □ Once the resistance is equal to 2kΩ (which may take up to 40 minutes), turn the ^{3}He pump heater down to 2 volts.
- □ Now wait up to four hours for the ^{3}He to condense in the pot (i.e., pick up with step 21 of *Step-By-Step Cycling of the ADR and 3He Fridge* on page 45 below). If you were already waiting for an hour or two before the power went out then you shouldn't need to wait the full four hours since some the ^{3}He will have already condensed in the pot before the power outage. However, this depends on how long the power was out. If

the power was out for more than 2-3 hours, all of the ^3He that condensed in the pot before the outage may now be evaporated.

- □ Finish the rest of the cycle (after step 21) as described in *Step-By-Step Cycling of the ADR and 3He Fridge* on page 45.

Case III. If the power went out at any other time during cycling, or if the system is warm for whatever reason, then you will have to re-cycle the ADR. See *Step-By-Step Cycling of the ADR and 3He Fridge* on page 43.

□ 5. Plug-in and reboot Fabry **(50)**. You don't need to log-on or anything, since this can all be done remotely when you telnet. Just push the power button.

□ 6. Power up the PZTs:

HOFPI

- □ Make sure the PZT cables are disconnected from the PI power supply **(38)**.
- □ Make sure channels 1, 2, & 3 are turned all the way down to 0V (fully *counterclockwise*) on the PI power supply.
- □ Turn on the PI power supply. Make sure all three channels (1, 2, & 3) still read 0V.
- □ Connect the PZT cables to the PI power supply. Make sure you match the correct cable with the correct channel (A ↔ 1, B ↔ 2, and C ↔ 3). Put the resistor caps which were on the cables on top of the PI power supply.
- □ Parallelize the HOFPI. Refer to the section below called *Parallelizing the Fabry-Perots* (page 53).

LOFPI (If applicable: We did not need to use the LOFPI PZT's over the Antarctic summer)

- □ Make sure the PZT cables are disconnected from the PI power supply **(39)**.
- □ Make sure channels 1, 2, & 3 are turned all the way down to 0V (fully *counterclockwise*) on the PI power supply.
- □ Turn on the PI power supply. Make sure all three channels (1, 2, & 3) still read 0V.
- □ Connect the PZT cables to the PI power supply. Make sure you match the correct cable with the correct channel (A ↔ 1, B ↔ 2, and C ↔ 3). Put the resistor caps which were on the cables on top of the PI power supply
- □ Parallelize the LOFPI. Refer to the section below called *Parallelizing the Fabry-Perots* (page 53).

□ 7. Turn on everything else:

- □ Calibration control box **(46)**: in the following order (and from left to right) turn on the main power switch, turn on the indexer, turn on the driver, and turn on the temperature control unit.
- □ Cryo-motor box **(48)**: in the following order, turn on the main power switch, turn on the indexers' power, and then turn on the HOFPI and LOFPI driver power. (You may need to turn this box off and turn it back on again after logging into Fabry, due to some initialization problem with the indexer that we don't fully understand. Make sure you always turn on the indexer before the driver, however.)
- □ SPIFI motor box **(49)**: in the following order, turn on the main power, then turn on switch "5."
- □ Turn on the battery box **(35)** by flipping Switch #1 on the battery box up. (Make sure all the other switches on the battery box are also in the correct positions! See page 58 for more details).
- □ Turn on the preamp **(11)** by moving the two left-most switches to "on" and "int" (both switches down).

The SPIFI Enclosure

Temperature

- **Check periodically to make sure the enclosure is still heated. The enclosure should not drop below 0°C.**
  - If the enclosure does drop below 0°C, lots of bad things can happen: Fabry will not operate properly and may be damaged; fans inside Fabry and inside other electronics boxes may be destroyed; other electronic components may malfunction; and the o-rings in SPIFI and the ADR can fail, in which case we would loose our vacuum.
  - If one of the heaters in the enclosure fails, replace it immediately.
  - Add more insulation or weather stripping to the enclosure if needed. Realize that the enclosure has never been tested under Antarctic winter conditions until now, and the winterovers may be called upon to make adaptations and improvements.
  - Perhaps the lights could be left on to add some additional heat. When you are observing and all the electronics boxes are running, these should add some heat as well. However, you should not leave the electronics running during months when SPIFI is not being used since this will cause them to wear out faster and could also cause extensive damage if the enclosure freezes while the fans and other electrical components are powered.
- Try to keep the doors closed as much as possible while filling and working in the enclosure to preserve heat.
  - While you are standing inside the enclosure, pull the door shut as far as possible behind you.
  - Always latch the doors when going back downstairs, even if you will be returning in a short time.

Mechanical

- Make sure the enclosure can clear all objects on the roof of AST/RO before rotating the telescope (such as Nitrogen tanks, etc.)
- Do not overload the pillbox **(2)**: the weight limit is approximately 40lbs.
- Do not push or pull on SPIFI when working in the enclosure or when climbing in and out of the enclosure or we could loose our alignment to the telescope.

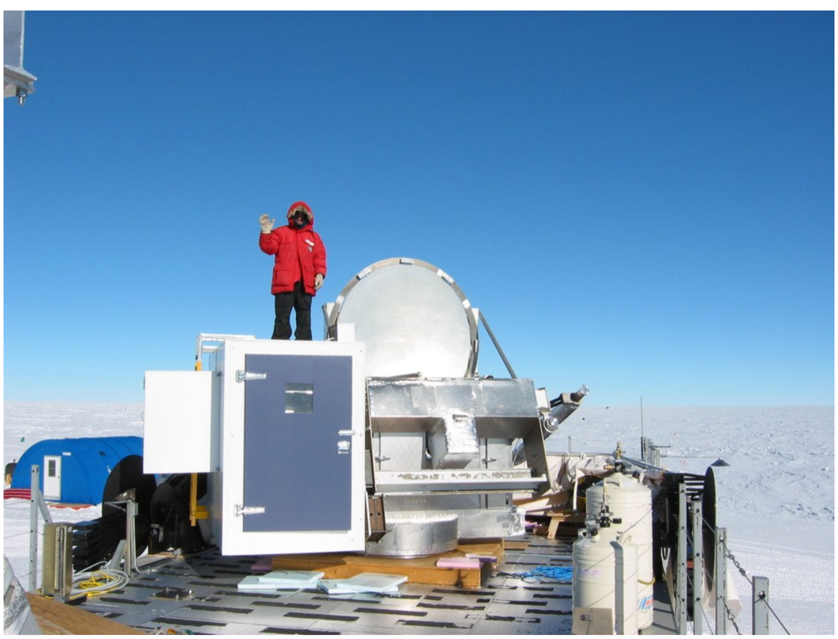


Figure 2: Steve stands triumphantly on top of the SPIFI enclosure

PART 1: PREPARATION

Pumping on SPIFI

Pumping SPIFI Down from a Partial Vacuum State

We left SPIFI under vacuum when we left the South Pole at the end of the 03-04 summer season. Therefore, the winterovers (you!) shouldn't have to pump down SPIFI from atmospheric pressure in winter 2004, although this full procedure is described in the next section below entitled *Pumping SPIFI Down from Atmospheric Pressure* for reference (and just in case). Nevertheless, SPIFI will have inevitably lost *some* pressure by June or July and will be in a "partial vacuum state." Use the steps below to reinitiate pumping on SPIFI from a partial vacuum state:

1. The main pump valve on SPIFI **(55)**, which is the big yellow-handled valve located above and to the left of the ADR/SPIFI interface, should be closed (see Figure 3 below). You shouldn't need to adjust it because we left it closed at the end of the summer. **Never open this valve if SPIFI is under vacuum and you suspect that the hose is not pumped down, or you could blow out the Fabry Perots!**
2. Make sure that both the turbo pump **(51)** and the pressure gauge for SPIFI **(57)** are plugged in (to 120VAC 60Hz). The turbo pump has a grey power cord and the pressure gauge has a black power cord.
3. Turn on the turbo pump station by pressing the main power button on the front of the pump once.
4. Listen to hear if the turbo pump is running smoothly. If it is not, let it run for a few minutes. Do not move on to the next step until the pump is running smoothly.
5. Pump out the vacuum hose between the turbo pump and the main SPIFI pump valve. Ideally we want to have the same pressure inside SPIFI and inside the vacuum hose before opening the main pump valve (equal pressure on both sides of the valve). To achieve this:
    a) If SPIFI is in the Torr range (> 1 Torr), run the turbo pump for about 1 minute before opening the main pump valve.
    b) If SPIFI is in the the sub-Torr range (< 1 Torr), run the turbo pump for 5-10 minutes before opening the main pump valve.

   Note that these times are not written in stone. You should use your best judgment to try to achieve an equal pressure on both sides of the main pump valve. There is no way to know for sure that the pressures are equal since there is no pressure gauge between the turbo pump and the main pump valve.
6. Once you have pumped out the vacuum hose, open the main SPIFI pump valve. The valve is spring loaded and can only be turned to either "open" or "closed." **Never open this valve if SPIFI is under vacuum and you suspect that the hose is not pumped down, or you could blow out the Fabry Perots!**
7. Once the pressure in SPIFI reaches about 5×10^{-3} - 8×10^{-3} Torr, the cool-down process can be started.
8. We would like you to keep records of pump-downs in the SPIFI notebook by creating a small table of pressure versus time. This will allow both us to properly gauge SPIFI's progress and to compare with records of past and future pump-downs.

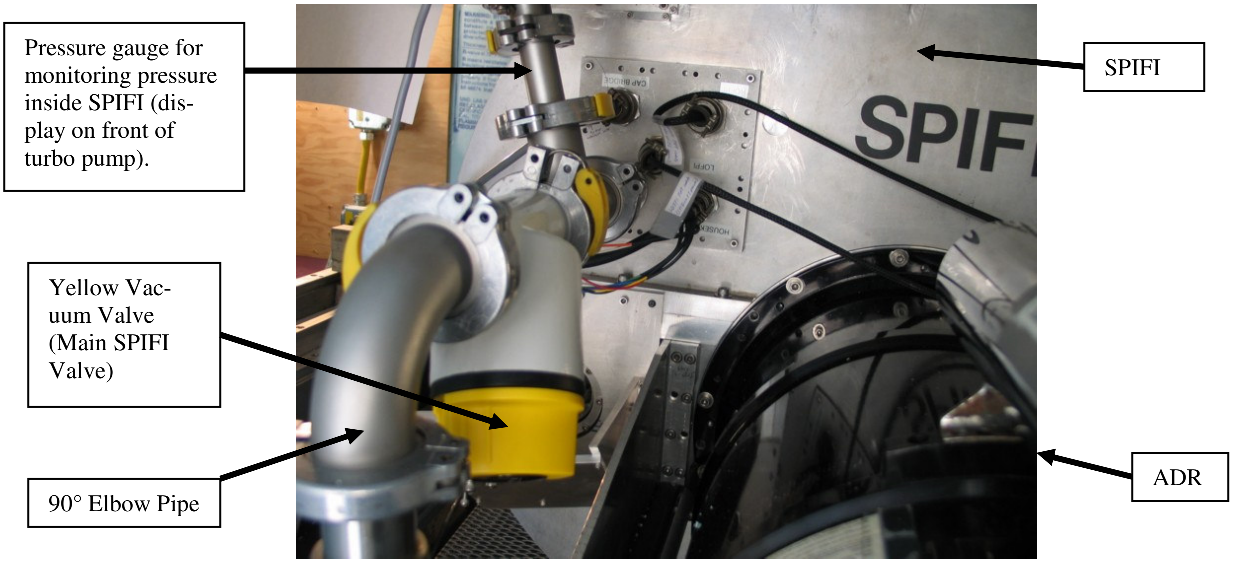


Figure 3: SPIFI Pump Manifold

Pumping SPIFI Down from Atmospheric Pressure

The basic procedure for pumping down SPIFI from atmospheric pressure is described here briefly for reference. (Note that the AST/RO winterovers should not have to pump down SPIFI from atmospheric pressure during the 2004 winter season, since we left SPIFI under vacuum when we left the South Pole at the end of the 03-04 summer season (see the section above: *Pumping SPIFI Down from a Partial Vacuum State*))

1. Attach the vacuum hose from the turbo pump to the yellow main pump valve for SPIFI **(55)** (via a 90° pipe). Make sure the o-rings and o-ring surfaces are clean, and make sure that the o-rings are slightly greased with vacuum grease. **Don't touch the yellow valve if SPIFI is under vacuum, or you could blow out the Fabry Perots!**
2. ***If you are sure SPIFI is at atmospheric pressure***, open the main yellow pump valve. The valve is spring loaded and can only be turned to either "open" or "closed."
3. Once the yellow valve is opened, then start the turbo pump station **(51)** by pressing the power button on the front of the pump once. This will start the diaphragm pump and the turbo pump simultaneously. The turbo pump is supposed to handle the torture of pumping at atmospheric pressure for a while.

The pump-down time to about 5×10^{-3} Torr is approximately 8 hours. However, this depends strongly on how long the SPIFI dewar was open to the atmosphere. If the turbo pump station can pump SPIFI down to the few Torr range within about 30 (to 40) minutes, then that is a good indication that everything is okay. The pressure should be in the mid-upper 10^{-2} Torr range within 2 – 3 hours. Once the pressure in SPIFI reaches about 5×10^{-3} - 8×10^{-3} Torr, the cool-down process can be started. Create a small table of pressure versus time in the SPIFI notebook while you are pumping down. This will allow you to properly gauge SPIFI's progress and to compare with records of past and future pump-downs.

(For your reference, after filling cryogens, the final pressure in SPIFI at the pumped l-^{4}He temperature of ~1.5K should get to between 5×10^{-7} and 1×10^{-6} Torr. This is discussed below on page 26).

Cooling SPIFI Down from 293K

Once the pressure in SPIFI reaches about 5×10^{-3} - 8×10^{-3} Torr, the cool down process can be started. The entire cool-down takes about two days. Our best estimates for the total cryogens used for a complete cool-down from room temperature are 170L l-N_2 and 150L l-^{4}He. So make sure you have this much cryogens on hand before you start.

The "SPIFI system" has four cryogen tanks:

- SPIFI l-N_2 tank (capacity = 25L)
- SPIFI l-^{4}He tank (capacity = 65L)
- ADR l-N_2 tank (capacity = 5L)
- ADR l-^{4}He tank (capacity = 5L)

The SPIFI tank necks are accessed through the roof hatches in the enclosure. The larger hatch **(6)**, which is closer to the telescope, is for the SPIFI l-N_2 tank neck **(30)**. The smaller hatch **(7)** is for the SPIFI l-^{4}He tank neck **(31)**. The ADR tank necks are accessed by opening the back double doors of the pillbox **(2)** on the enclosure. The ADR l-^{4}He tank neck **(9)** is labeled "Helium," and the ADR l-N_2 tank neck **(10)** is labeled "Stickstoff" (which means "Nitrogen" auf Deutsch).

Because the necks of the ADR's cryogen tanks are horizontal, it is not possible to directly measure the level of cryogens in these tanks. However, keeping careful records of times and amounts of fills in the SPIFI notebook will help you to make close estimates of the cryogen levels and stay on top of the ADR's tanks. Although we never want to let the cryogens in SPIFI or the ADR run out once SPIFI has been cooled down to l-^{4}He temperature, if you do suspect that you have accidentally run out of cryogens in either of the ADR's horizontal tanks you can use the trick of holding your thumb over the neck vent for a minute or so and then letting go. If a plume of gas comes out afterwards then you still have cryogens left.

In SPIFI it will be necessary for you to monitor the levels of cryogens in the two SPIFI tanks while you fill. You can check the level of SPIFI's l-N_2 tank using Steve's **hand-carved** wooden dipper stick (which we usually store on the SPIFI alignment table **(32)** inside the enclosure on the battery box side of SPIFI):

Figure 4: Steve's *Hand-Carved* Wooden Dipper Stick

To measure the l-N_2 level in SPIFI, put the blue end of the stick all the way down into SPIFI's l-N_2 neck until it touches the bottom of the tank and hold it there for 10-20 seconds. Remove the stick and blow on the end of it several times to create a frost line. Use a tape measure to measure the height of the frost line and record it in the SPIFI notebook. The height of cryogens in the l-^{4}He tank can be measured by traditional means, such as by using a thumper. Also record this height in the SPIFI notebook. Once you have measured the height in either SPIFI's l-N_2 or l-^{4}He tank, you can use Table 7 in *Appendix A* to convert your measurement to a volume.

We will begin the cool-down process by filling all four cryogen tanks with l-N_2. Be careful not to fill too much l-N_2 into the two l-^{4}He tanks, or else you will have the problem of getting this l-N_2 out when it comes time to fill l-^{4}He and you may loose time and waste cryogens. Also, it is important to initially fill very slowly---with a "low" N_2 pressure (~1-1.5 psi in the fill Dewar). If you fill quickly with high pressure, the boil-off in the tanks may create a dangerous over-pressure inside the reservois. Keep a record in the SPIFI notebook while you are cooling down of what times you filled which tanks, how full they are, how long it took to fill them, and how much cryogens where used in the process. This will help you keep track and gauge the progress of the cool-down process, and will allow us to compare the present cool-down with records of past and future cool downs

1. Close all the heat switches on the ADR (pot **(19)**, pump **(20)**, and pill **(21)**) to make sure everything will get cold.
2. First slowly (~1-1.5 psi in the fill Dewar) fill l-N_2 into the ADR l-N_2 ("Stickstoff") tank until it's full (use the procedure described in the section *ADR Nitrogen* on page 32 below). This normally takes about 15 minutes. Record in the SPIFI notebook the time of the fill, how long it took to fill, and estimate (if you can) how many liters of cryogens were used.
3. Then slowly (~1-1.5 psi in the fill Dewar) fill l-N_2 into the SPIFI l-N_2 tank until its full (use the procedure described in the section *SPIFI Nitrogen (with no pump attached)* on page 33 below). If the vacuum hose and special stinger assembly are still attached to the SPIFI l-N_2 tank you will have to remove them first (**See** Figure 12 **page 34 for a detailed diagram of the special stinger and pumping assembly)**. (While cooling down SPIFI, the pressure should decrease, as indicated on the LCD display on the front of the turbo pump **(51)**.) We once measured that to get about 7 inches of l-N_2 in this tank from room temperature takes about 1½ hours (maximum fill height is 11 inches). The 50L l-N_2 Dewar won't last for both the ADR l-N_2 tank fill and the SPIFI l-N_2 tank fill, and you will have to refill the Dewar once before you can top-off the SPIFI l-N_2 tank. Record in the SPIFI notebook the time of the SPIFI l-N_2 tank fill, how long it took to fill, the level of cryogens in the tank, and estimate (if you can) how many liters of cryogens were used.
4. Next fill l-N_2 slowly (~1-1.5 psi in the fill Dewar) into the ADR l-^{4}He tank (use the procedure described in the section *ADR Nitrogen* on page 32 below). Since SPIFI cannot be tilted when it's in the enclosure, it is difficult to get the l-N_2 out of the l-^{4}He tank once the tank reaches 77 K. In this case what we usually do is fill 1-2 liters of l-N_2 and watch the temperature (by temporarily closing the pill heat switch and watching the GRT, for instance). (See *Temperature Monitoring* below on page 29.) Once the temperature stabilizes or starts to increase, fill another liter or so of l-N_2 into the l-^{4}He tank. Continue this process until the temperature stabilizes close to 77 K. To be conservative, stop filling l-N_2 when the temperature reaches about 85 – 90 K. (The last time we filled we found that two full fills of the ADR l-^{4}He tank was too much). One full fill takes about 15 minutes. Record info about the fill in the SPIFI notebook.
5. Top-off the ADR l-N_2 tank again with l-N_2. Record in the notebook.
6. Lastly, fill the SPIFI l-^{4}He tank slowly (~1-1.5 psi in the fill Dewar) with l-N_2 (use the procedure described in the section *SPIFI Nitrogen (with no pump attached)* on page 33 below). This fill will take a long time (1½ – 2 hours). Check the level after filling for 1–1½ hours to make sure you don't get more than 3 inches of l-N_2 in the tank (or you may have trouble blowing it out later and you will waste it). One to two inches of l-N_2 in this tank should be enough. You may need to refill the 50L l-N_2 Dewar during this fill. Record in the SPIFI notebook the time of the fill, how long it took to fill, the level of cryogens in the tank, and estimate (if you can) how many liters of cryogens were used.
7. Top off the ADR l-N_2 tank once more with l-N_2. Record in the notebook.
8. After everything reaches 77K, SPIFI should achieve a pressure of ~10^{-6} Torr (indicated on the turbo pump **(51)**). Record the pressure and the time of the reading in the SPIFI notebook.

Wait about a day before filling helium. **Before filling l-^{4}He into SPIFI or the ADR check if the HOFPI is parallel at l-N_2 temperatures.** (See *Parallelizing the Fabry-Perots* on page 53 below). If the HOFPI is way out of parallel, SPIFI will not work properly and it would be a waist of l-^{4}He trying to operate SPIFI. Record the state of the parallelism in the notebook. Also, it is important to get all of the l-N_2 out of the l-^{4}He tanks before filling l-^{4}He:

9. Parallelize the HOFPI (See *Parallelizing the Fabry-Perots* on page 53 below).
10. If there is still l-N_2 in the ADR l-^{4}He tank, blow it out using the special ADR blow-out invention (see Figure 8 on page 28 below), which we stored in the SPIFI crate labeled "A2" in the AST/RO Annex. Record how much l-N_2 needed to be blown out in the notebook.
11. Hopefully at this point there is no l-N_2 still left in the ADR l-^{4}He tank. Just in case there is, heat the tank with the pump heater **(25)** and the persistent switch heater **(24)**:
    a) connect the housekeeping cable **(27)** to the ADR.
    b) Make sure the pump heat switch **(20)** is closed.

c) Turn on the pump heater **(25)** (the small green power supply in the bottom-left corner inside the pillbox doors) and set it to 5V.
d) To use the persistent switch heater, you will have to turn on the power of both magnet control boxes simultaneously **(22)** & **(23)**, and wait a half-minute or so until you hear the fans in these boxes have started up and are running smoothly: the fans in these boxes don't like the cold.
e) Next, turn the keyed persistent switch **(24)** on by rotating the key 90° clockwise (see Figure 15 on page 47).

Turning on these two heaters will heat up the ^{4}He tank and the remaining l-N_2 will hopefully evaporate. But don't heat it up too much! I.e., try to keep the ADR below 90K (you can monitor the temperature by closing the pill heat switch and watching the GRT, for instance (see *Temperature Monitoring* on page 29 below)).

12. Once the ADR l-^{4}He tank has no l-N_2 in it, fill it completely with l-^{4}He. Make sure you use a low pressure when filling with l-^{4}He for the first time (~1-1.5 psi in the fill Dewar). If you fill too quickly with too high of a pressure then the tank may become over-pressured and leaks in the l-^{4}He neck could develop. This fill takes about 30 minutes. Record in the SPIFI notebook the time of the fill, how long it took to fill, and estimate (if you can) how many liters of cryogens were used.
13. Blow all of the l-N_2 out of the SPIFI l-^{4}He tank using the special SPIFI blow-out device (see Figure 6 on page 27 below), which is stored in the SPIFI crate labeled "?" in the AST/RO Annex. Record how much l-N_2 you blew out in the manual. You can use a funnel to pour the blown-out l-N_2 into the SPIFI l-N_2 tank so it does not go to waste.
14. Fill the SPIFI l-^{4}He tank completely with l-^{4}He (use the procedure described in *SPIFI Helium* on page 36 below). Make sure you use a low pressure when filling with l-^{4}He for the first time (~1-1.5 psi in the fill Dewar). If you fill too quickly with too high of a pressure then the tank may become over-pressured and leaks in the l-^{4}He neck could develop. This fill takes a while and it might be necessary to stop and top-off the ADR l-^{4}He tank again before the SPIFI l-^{4}He tank is full. We have estimated that within about one hour you will get approximately 1.5 inches of l-^{4}He in the SPIFI l-^{4}He tank. A complete fill takes about 2-3 hours. You will run out of l-^{4}He in the 100L Dewar before you can complete the fills of both SPIFI's and the ADR's l-^{4}He tanks. Therefore, make sure you have enough l-^{4}He (~150L) on hand before you start. Record in the SPIFI notebook the time of the fill, how long it took to fill, the level of cryogens in the tank, and estimate (if you can) how many liters of cryogens were used.

After completely filling the l-^{4}He tanks (steps 12 and 14 above), SPIFI should optimally be able to achieve a pressure between 5×10^{-7} and 1×10^{-6} Torr. The first cool-down uses a lot of cryogens. Since the ADR's cryo-tanks are small they will run out of cryogens quickly and **it will be necessary to fill the ADR cryo-tanks again after about 6 - 8 hours**. (Remember, a good way to check if the ADR's tanks still have cryogens is to hold your thumb over the neck vents for a minute or so and then release. If you see a plume of cold gas then there are still cryogens in the tank).

15. After ~ 6-8 hours, top-off the ADR's cryo-tanks. Record in the SPIFI notebook the time of the fill, how long it took to fill, and estimate (if you can) how many liters of cryogens were used.
16. About one day after the cool-down from 293K was started, you can start pumping on the ADR l-^{4}He tank:
    a. First make sure that the main valve on the ADR l-^{4}He pump manifold is closed **(16)**.
    b. Make sure the gas inlet valve **(18)** on the manifold is open (to allow boil-off to escape to atmosphere so you don't get an overpressure).
    c. Insert and secure the KF end-cap and clamp assembly **(9)** with the red vacuum hose **(14)** attached into the ADR l-^{4}He neck. The o-ring of the KF cap should be clean and slightly greased with vacuum grease so that you get a good seal. When you attach the red vacuum hose, the hose should come off the of the top-left of the neck (higher than horizontal: see the picture in the *Inside the Pillbox* section of the *SPIFI Quick Locator Guide* on page 6 above). Also, make sure the KF end-cap and clamp assembly is oriented so that the red vacuum-hose cap of the Stickstoff neck is not blocked.

d. Start the appropriate pumpzilla in the receiver room by flipping the switch on the breaker box on the wall.
e. Close the gas inlet valve **(18)** on the manifold and go immediately to the next step.
f. Slowly reopen the main valve **(16)** on the vacuum manifold. Take at least 5 minutes to completely open this valve to minimize stress on the pump. You won't be able to listen to the pump because it is downstairs, so use your best judgement (although Steve claims he can hear the change in the pump through its exhaust). You should eventually see the pressure drop on the pressure gauge, once it gets below 100 Torr (the gauge has a range of 0-100 Torr). The needle may oscillate wildly. This is normal. Sometimes you can dampen these oscillations by opening or closing the valve a bit. The oscillations usually dampen out on their own once the pressure gets below about 30 Torr. After some time (½ hour or so after fully opening the main valve) the pressure should get below 10 Torr. Make a record of this in the SPIFI notebook. Eventually you will want ~3 Torr.

17. Either during or after you have pumped down the ADR l-^{4}He tank you will need to close the green Swagelok valve on the side of the ADR to seal off the ^{3}He tank. This is the first green-colored valve handle on the "top right" of the ADR, as viewed when looking in through the pillbox doors (see Figure 5 below). This must be closed before cycling the ADR. **Don't touch the other green Swagelok valve (further back on the ADR) or you will release all our ^{3}He to the atmosphere!**
18. You can also start pumping on SPIFI's l-N_2 tank at the time that you start pumping on the ADR l-^{4}He. First, reconnect the vacuum hose and special stinger assembly to the SPIFI l-N_2 neck. We left the vacuum hose and special stinger assembly for pumping on SPIFI's l-N_2 tank connected to SPIFI's l-N_2 neck at the end of the 03-04 summer season at Pole. However, you had to remove this assembly in step 3 above in order to fill l-N_2. **See Figure 12 page 34 for a detailed diagram of the special stinger and pumping assembly.**
    a) Make sure the brass valve connecting SPIFI's l-N_2 neck to the vacuum hose is closed.
    b) Make sure the yellow latex hose is securely clamped off near the end which connects to the stainless steel stinger.
    c) Start the appropriate pumpzilla in the receiver room by flipping the switch on the breaker box on the wall.
    d) Slowly open the brass valve on SPIFI's l-N_2 neck. Don't open the valve too fast, or you will overload the pump. It will be difficult to gauge this, since the pump is downstairs and you can't hear it (although Steve claims he can hear the change in the pump through its exhaust). But because we use the same type of pump on SPIFI's l-N_2 as we do to pump on the ADR's l-^{4}He, the pump-down rate should be similar. Record the time that your pump-down started in the SPIFI notebook.
19. Check the ambient temperature inside the SPIFI enclosure after filling to make sure its still warm. By "warm", we mean above 0°C: we *never* want the enclosure to get much colder than this. If the enclosure is below 0°C, take measures to warm it up. This may involve simply keeping the doors of the enclosure closed for a while and letting the heaters in there do their jobs. I could also involve adding another heater or more weather stripping and insulation if needed.
20. Only if the enclosure is above 0°C, turn on all the electronics in the enclosure to help with heating:
    a) Calibration control box **(46)**: in the following order (and from left to right) turn on the main power switch, turn on the indexer, turn on the driver, and turn on the temperature control unit.
    b) Turn on the resistance bridge box **(47)**.
    c) Cryo-motor box **(48)**: in the following order, turn on the main power switch, turn on the indexers' power, and then turn on the HOFPI and LOFPI driver power. (You may need to turn this box off and turn it back on again after logging into Fabry, due to some initialization problem with the indexer that we don't fully understand. Make sure you always turn on the indexer before the driver, however.)
    d) SPIFI motor box **(49)**: in the following order, turn on the main power, then turn on switch "5."
21. Boot-up Fabry **(50)**. You don't need to log-on or anything, since this can all be done remotely when you telnet. Just push the power button. *But only turn on Fabry if the temperature is above 0°C!*
22. Parallelize the HOFPI again (See *Parallelizing the Fabry-Perots* on page 53 below).

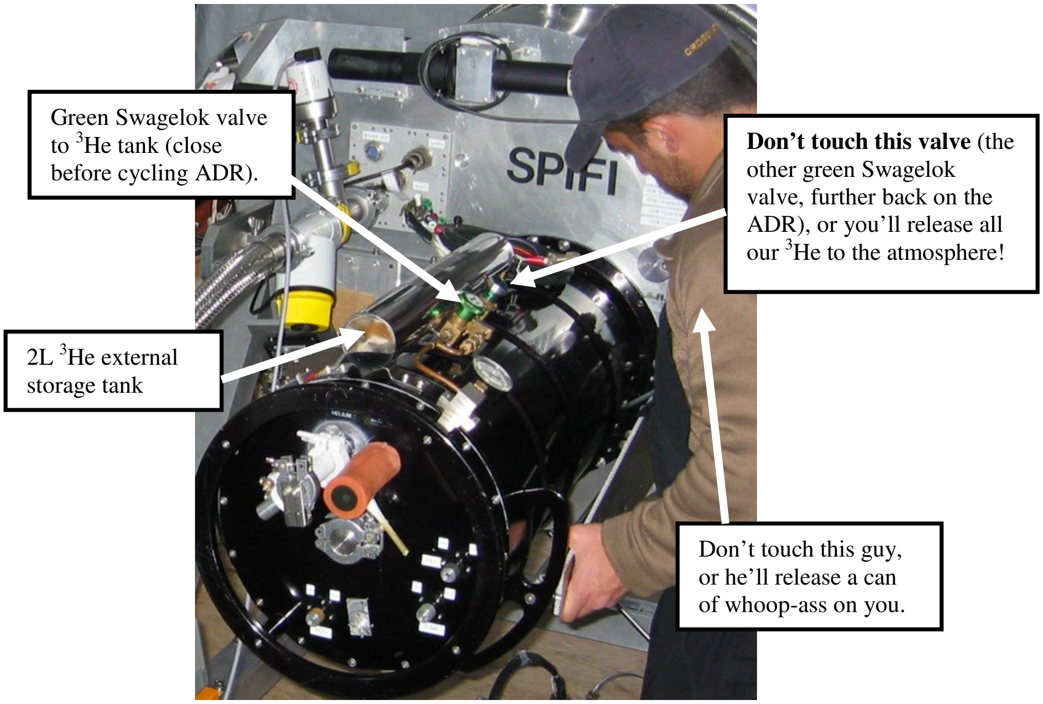


Figure 5: Swagelok Valve to ADR ^{3}He tank

Good job: you're done with the initial cool-down. SPIFI should be getting very cold by now. Watch the pressure on the turbo pump and see if it gets between 5×10^{-7} and 1×10^{-6} Torr (and record the pressure in the SPIFI notebook). Also, check the GRT's and SPIFI's carbon resistors to monitor the temperature (see *Temperature Monitoring* on page 29). Keep a record in the SPIFI notebook every time you check the temperatures.

Now your only worry is to make sure the tanks never run out of cryogens. Refer to *Maintenance Filling* on page 32 below for regular filling methods and schedules.

Figure 6: Blowing l-N_2 Out of the SPIFI l-^{4}He Tank

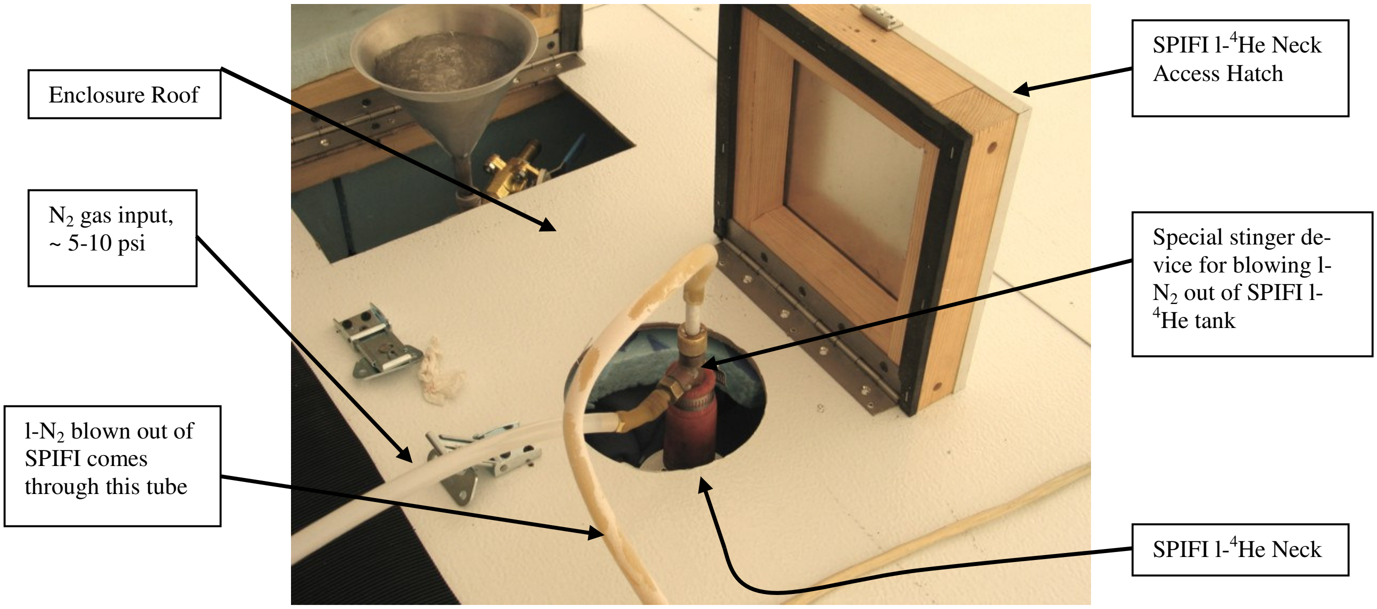


Figure 7: Pouring l-N_2 blown out of SPIFI's l-^{4}He tank into SPIFI's l-N_2 tank

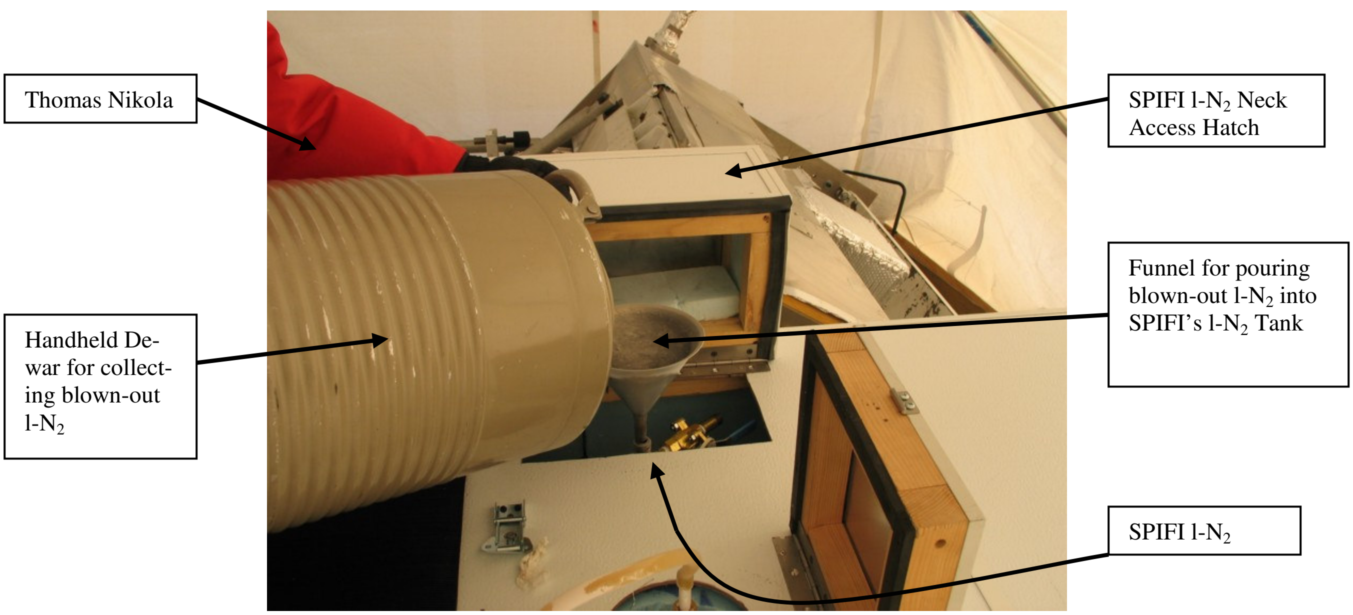
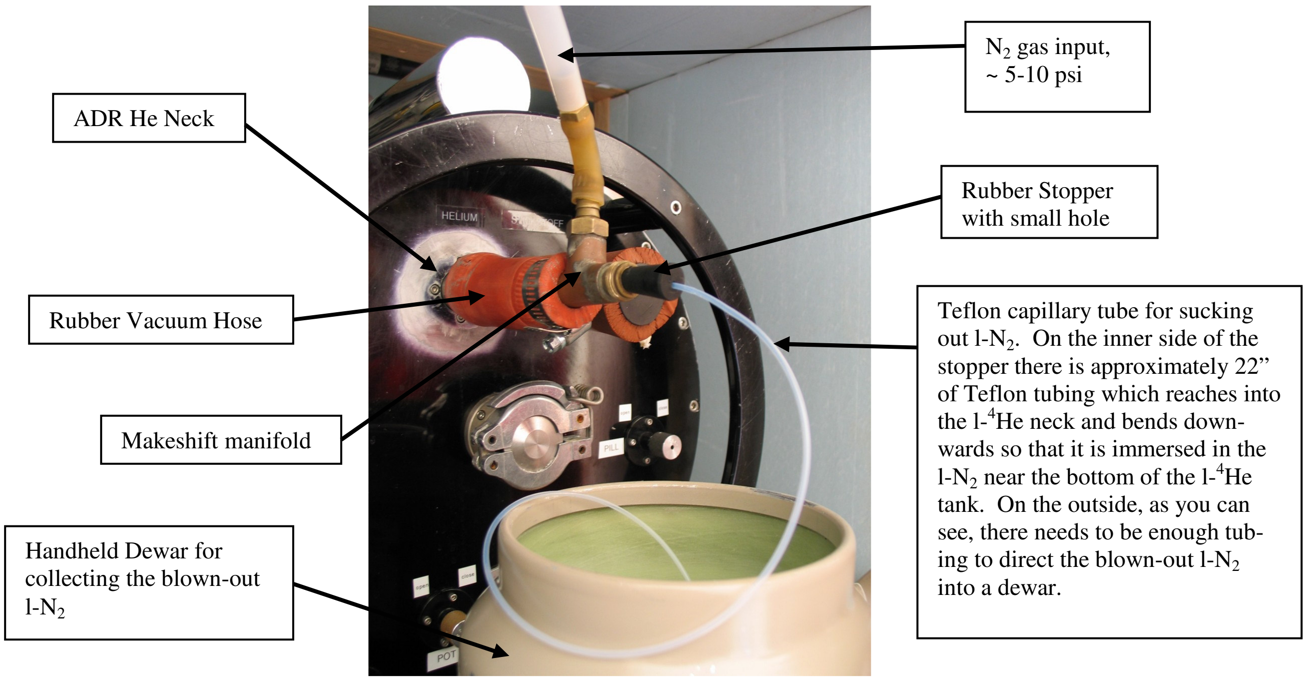
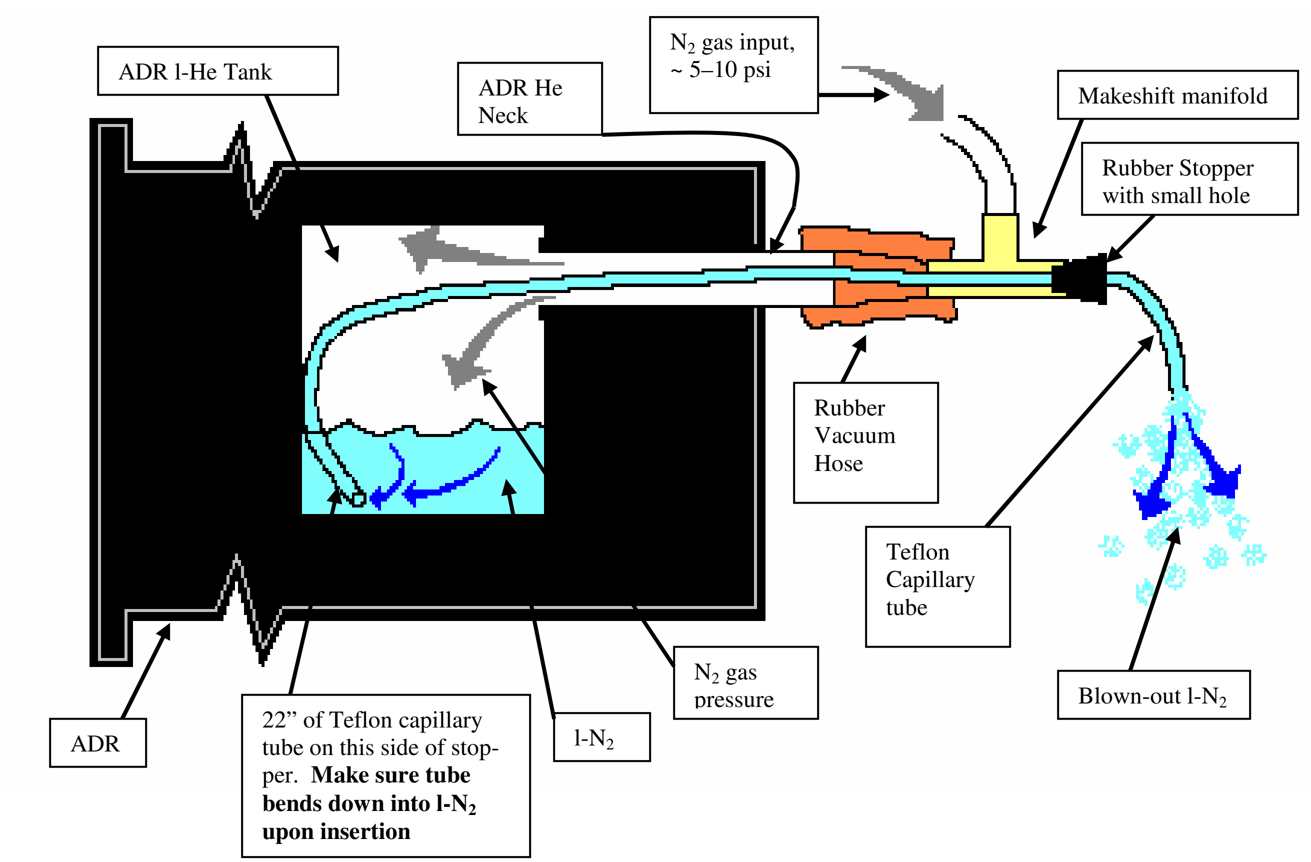


Figure 8: Blowing l-N_2 Out of the ADR l-^{4}He Tank





PART 2: OPERATION

Temperature Monitoring

SPIFI Temperature Check

SPIFI has four carbon resistors inside. The leads of these carbon resistors **(52)** are hanging over the edge of the SPIFI alignment table **(32)** on the Fabry side of SPIFI. The leads are female banana sockets colored red, green, white, and black, with two sockets of each color. To determine SPIFI's temperature we usually only use the red and white resistors:

1. Record in the SPIFI notebook the resistance across the red pair of banana sockets and the white pair of banana sockets.
2. Use the calibration chart below to interpret the temperature of the red resistor based on your measured resistance. The red resistor is tied to the LOFPI stage (4.2K stage) in SPIFI's main Dewar.
3. Use the calibration chart below to interpret the temperature of the white resistor based on your measured resistance. The white resistor is tied to the HOFPI stage (77K stage) in SPIFI's main Dewar.

White Resistor (kΩ) HOFPI 77K stage	**Red Resistor (kΩ) LOFPI 4.2K stage**	**Temperature (°C)**	**Temperature (K)**
9.31	10.8	22.6	295.6
9.32	10.8	21.0	294.0
9.36	10.8	15.0	288.0
9.40	10.8	10.0	283.0
9.48	10.9	0.0	273.0
9.57	10.9	-10.0	263.0
9.66	10.9	-20.0	253.0
9.75	11.0	-30.0	243.0
9.86	11.1	-40.0	233.0
9.97	11.1	-50.0	223.0
10.08	11.2	-60.0	213.0
10.21	11.4	-70.0	203.0
10.34	11.5	-80.0	193.0
10.49	11.7	-90.0	183.0
10.65	11.9	-100.0	173.0
10.84	12.1	-110.0	163.0
11.04	12.4	-120.0	153.0
11.27	12.7	-130.0	143.0
11.53	13.1	-140.0	133.0
11.82	13.6	-150.0	123.0
13.16	15.4	-180.0	93.0
13.31	16.0	-183.5	89.5
13.34	16.2	-184.5	88.5
13.36	16.3	-185.8	87.2
13.39	16.4	-187.1	85.9
13.41	16.5	-187.9	85.1
13.43	16.6	-189.4	83.6

Table 1: Temperatures for SPIFI's Carbon Resistors

ADR Temperature Check

The temperature in the ADR is monitored through two GRT's. One is located on the salt pill and the other on the ^{3}He pot.

1. Plug the housekeeping cable **(27)** into the ADR. This is the large black braided cable with the military style connector. It plugs into the bottom-right underside of the end of the ADR near the double pillbox doors. The connector is *not* a bayonet-style or screw-on. Rather, just push it straight in snuggly.
2. Next, locate the small blue box **(56)** on the inner right-hand wall of the enclosure on the Fabry side of SPIFI. A knob to select which GRT you wish to read is located on the box. Select either position "3: Pill" or position "2: Pot." See Figure 9 below.

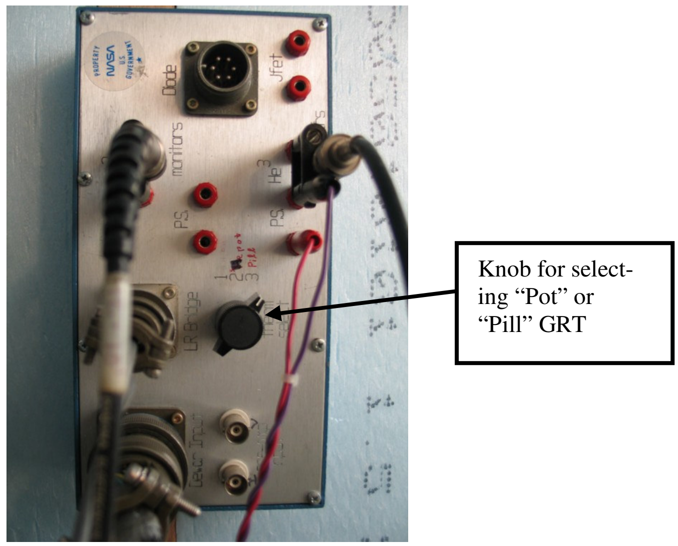


Figure 9: Selecting Pill & Pot GRT's on the Small Blue Box (56)

3. After selecting which GRT you want to use on the small blue box, locate at the Resistor Bridge Box **(47)** in the electronics rack (second box from the top of the electronics rack on the Fabry side of SPIFI in the enclosure). If the Resistance Bridge is not already on, turn it on.
4. Wait several minutes for the resistance to climb and stabilize at its actual value.
5. Once the resistance has become stable (or is bouncing around some mean value), record the resistance in the SPIFI notebook.
6. Compare your recorded value with the graph below (Figure 10) to get the temperature, and record this temperature in the SPIFI notebook. Figure 10 is a very rough linear approximation for "high" temperatures (say, above 10K). We do not have good calibration measurements of these GRT's for temperatures below 4K. However, after cycling the ^{3}He fridge and the ADR, and when the system is cold enough for observing, the pot GRT should read something on the order of 120Ω (which means the pot is around 275mK), and the pill GRT should read something between 700Ω up to 5kΩ (which means the pill and detectors are around 60mK). The wide range of 700-5000Ω is because the resistance-temperature curve of the GRT for very low temperatures is very steep. Therefore a large increase in resistance only corresponds to a small decrease in temperature. Also, you should know that the pill GRT doesn't always appear to be stable, and can jump around a bit.
7. When finished **unplug the housekeeping cable**. If the housekeeping cable is left in, it can add considerable noise to the signal while taking scans. It can also cause a heating of the detectors due to microphonics and the bias current for the GRTs. You can leave the Resistor Bridge Box turned on however to help with enclosure heating.

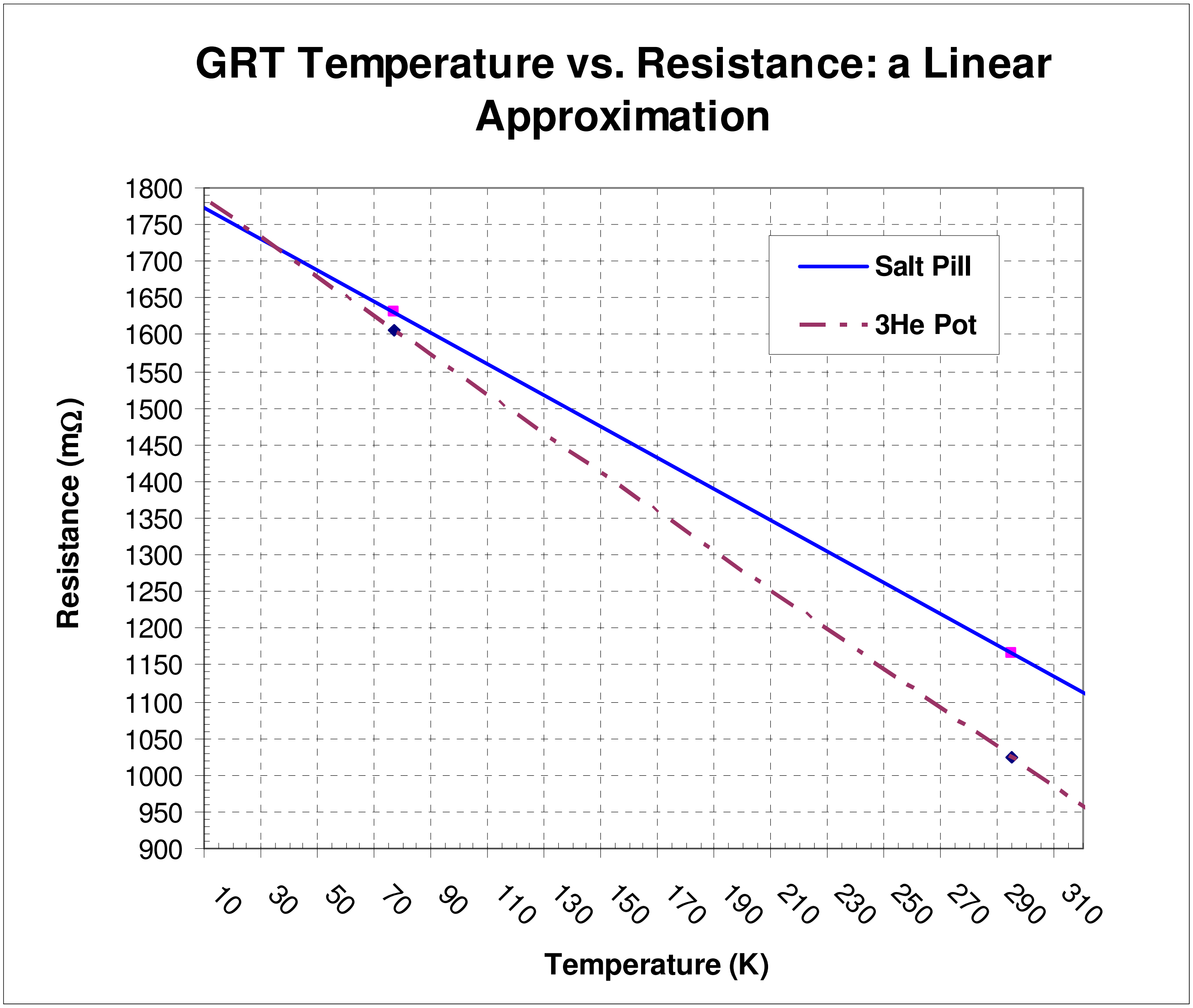


Figure 10: GRT Temperature vs. Resistance Plot

Maintenance Filling

Table 2 below summarizes the most important facts you need to know about maintenance filling for the four cryogen tanks in the "SPIFI system" (see page 22 for an introduction to SPIFI's four cryo-tanks). When checking the level of cryogens in SPIFI's l-N_2 and l-^{4}He tanks, you may also need to refer to the height versus volume chart for SPIFI's tanks, which is found in *Appendix A* on page 64 (Table 7). Keep records in the SPIFI notebook every time you check the levels in these tanks. Note that from the values shown in Table 2, one can assume an average usage of about 17L of l-N_2 per day, and about 25L of l-^{4}He per day.

Table 2: Summary of Cryogen Tank Maintenance Filling

Tank	**Recommended to refill every…**	**Recommended to check level every…**	**Cryogens needed per fill***	**Maximum hold time**	**Capacity of tank (L)**
ADR l-N_2	22 hours (or more often when cycling)	not possible	6-7L l-N_2	22 hours	5
SPIFI l-N_2 (no pump)	2 days	1 day (use Steve's hand-carved wooden dipper), + before and after fills	20L l-N_2	3 days	25
SPIFI l-N_2 (with pump)	1 day	not possible	10L l-N_2 *minimum* (make sure it doesn't suck air)	(same as above)	(same as above)
ADR l-4He	1 day (or more often when cycling)	not possible	8-10L l-^{4}He	1 day	5
SPIFI l-^{4}He	5-7 days	check 3 days after a fill, then check more often as needed (use thumper). Also check immediately before and after any fill.	100L l-^{4}He (never start filling with a partially full 100L Dewar)	7 days	65

*Assuming you refill according to the recommendations in column two.

Detailed instructions for maintenance filling follow in the subsections below. Keep a record in the SPIFI notebook for every fill. Record the time of the fill, the level of cryogens in the tank before and after the fill (if this can be measured), how long the fill took, and estimate (if you can) the amount of cryogens that were used for the fill. These notes will help you keep track of the maintenance filling schedule---namely of what tanks need filled when. They will also allow you to make estimates of SPIFI's boil-off rate, and help us make sure SPIFI is behaving well.

ADR Nitrogen

The ADR l-N_2 tank must be filled approximately once every 22 hours. Because the ADR is horizontal, there is no way to check the level in the ADR l-N_2 tank (although you can hold your thumb over the vent for a short while and then release to see if you see a plume---if you do, then there is still l-N_2 in the tank), so it is important to fill on time. The capacity of the tank is 5L, so it should take about 6-7L of l-N_2 to fill.

1. Attach the curved copper extension onto the 50L l-N_2 Dewar using a crescent wrench. Next, attach the yellow latex hose---with the stainless steel stinger on the other end---to the end of the copper extension using a hose clamp. (Note that if the yellow latex hose is too stiff in the Antarctic winter you may need to switch to Teflon). The copper extension should be rotated so that it curves upwards. (See Figure 11 below.)
2. Position the 50L Dewar midway between the end of the pillbox and the baby-buggy cover.

3. Remove the red vacuum hose cap from the ADR's l-N_2 ("Stickstoff") neck **(30)**.
4. Before opening the l-N_2 valve on the Dewar, make sure the yellow latex hose (or Teflon hose) is not kinked near the end of the copper extension. Also make sure the stainless steel stinger is held at the height of the Stickstoff neck and is parallel to the ground.
5. Slowly open the l-N_2 valve on the Dewar.
6. Just when the hose starts to get stiff, insert the stinger in the Stickstoff neck and move the entire Dewar towards the pillbox until the stinger is inserted all the way into the Stickstoff neck. The stinger should be inserted as far as possible until it hits the bottom of the ADR's l-N_2 tank, and then should be backed off a half-inch or so to allow the l-N_2 to flow freely from the end of the stinger.
7. When the ADR's l-N_2 tank is full, shut off the main valve on the Dewar.
8. Move the Dewar back towards the baby-buggy cover to remove the stinger from the Stickstoff neck.
9. Replace the red vacuum hose cap on the Stickstoff neck.
10. Make sure the pillbox doors are closed and latched.

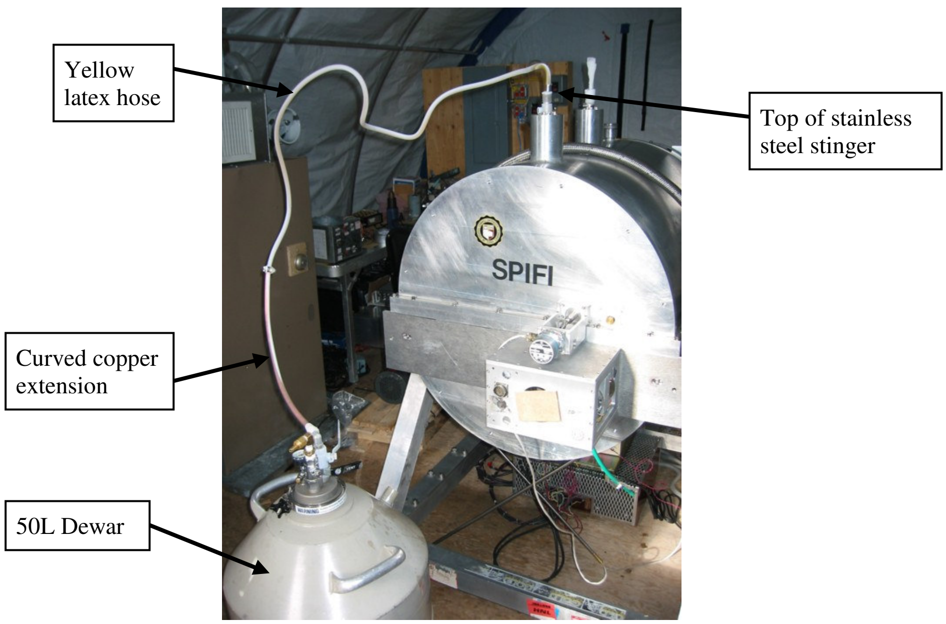


Figure 11: Filling SPIFI's l-N_2 Tank from the 50L Dewar

SPIFI Nitrogen (with no pump attached)

The tank should be filled approximately every two days. The *maximum* hold time for this tank is three days, but check the level *every day* to make sure you don't run out sooner (use Steve's **hand-carved** wooden dipper stick---see Figure 4 and instructions for use on page 22 above). If you fill every day, SPIFI will drink about 10L of l-N_2. If you wait two days, it will drink about 20L. The capacity of the tank is 25L.

One other note: the method described below of putting the 50L l-N_2 Dewar inside the enclosure with the door partly open behind it worked well in the summer. However, in wintertime if this causes too much heat loss inside the enclosure---which it very well may---you might try putting the 50L Dewar on the lift, jacking it up, and just filling through the roof hatch from the outside. This is especially true if Fabry and other electronics are running: if it drops below 0°C inside the enclosure Fabry and fans inside electronics boxes may be destroyed.

1. Check the level of l-N_2 in the tank before filling and record this value and the time in the SPIFI notebook.
2. Attach the curved copper extension onto the 50L l-N_2 Dewar using a crescent wrench. Next, attach the yellow latex hose---with the stainless steel stinger on the other end---to the end of the copper extension using a hose clamp. (Note that if the yellow latex hose is too stiff in the Antarctic winter you may need

to switch to Teflon). The copper extension should be rotated so that it curves upwards. (See Figure 11 above.)

3. Lift the 50L Dewar up and set it into the enclosure on the battery box side of SPIFI (or alternatively jack it up on the lift on the outside of the enclosure). **Do not pull or push on SPIFI** or the SPIFI alignment table **(32)** while doing this, or we could loose our alignment to the telescope. Rotate the Dewar so that the copper extension is pointed upwards and towards the telescope wall of the enclosure (front of SPIFI).
4. Open the roof hatch above SPIFI's nitrogen neck **(30)**. This is the larger hatch (closest to the telescope side of the enclosure).
5. Snake the yellow latex hose (or Teflon hose if latex is too stiff in the winter) through the roof hatch, and insert the stinger into the l-N_2 neck. (If the hose does not reach, then rotate the copper extension or the 50L Dewar until it does---or else get a longer hose).
6. Making sure there are no kinks in the yellow tubing (or Teflon tubing), open the 50L Dewar's main valve and fill SPIFI's l-N_2 tank.
7. When SPIFI is full, close the main valve on the 50L Dewar.
8. Let the yellow hose (or Teflon hose) thaw and remove the stinger from SPIFI
9. Remove the 50L Dewar from the enclosure (or lower it from the lift).
10. Make sure the enclosure side door and roof hatch are shut and latched.
11. Record in the SPIFI notebook the time of the fill, how long it took to fill, the level of l-N_2 in the tank, and estimate (if you can) how many liters of l-N_2 were used.

SPIFI Nitrogen (with pump attached)

When we pump on the SPIFI l-N_2 tank, there is no way to measure the level of l-N_2 in the tank (not even with ingenious **hand-carved** tools made by Steve). Therefore we must fill this tank every day to make sure it doesn't run dry. When filling every day, SPIFI's l-N_2 tank will drink about 10L of l-N_2 per fill. **Make sure that you have *at least* 10L available. If the l-N_2 tank starts sucking on air you'll get an ice plug!**

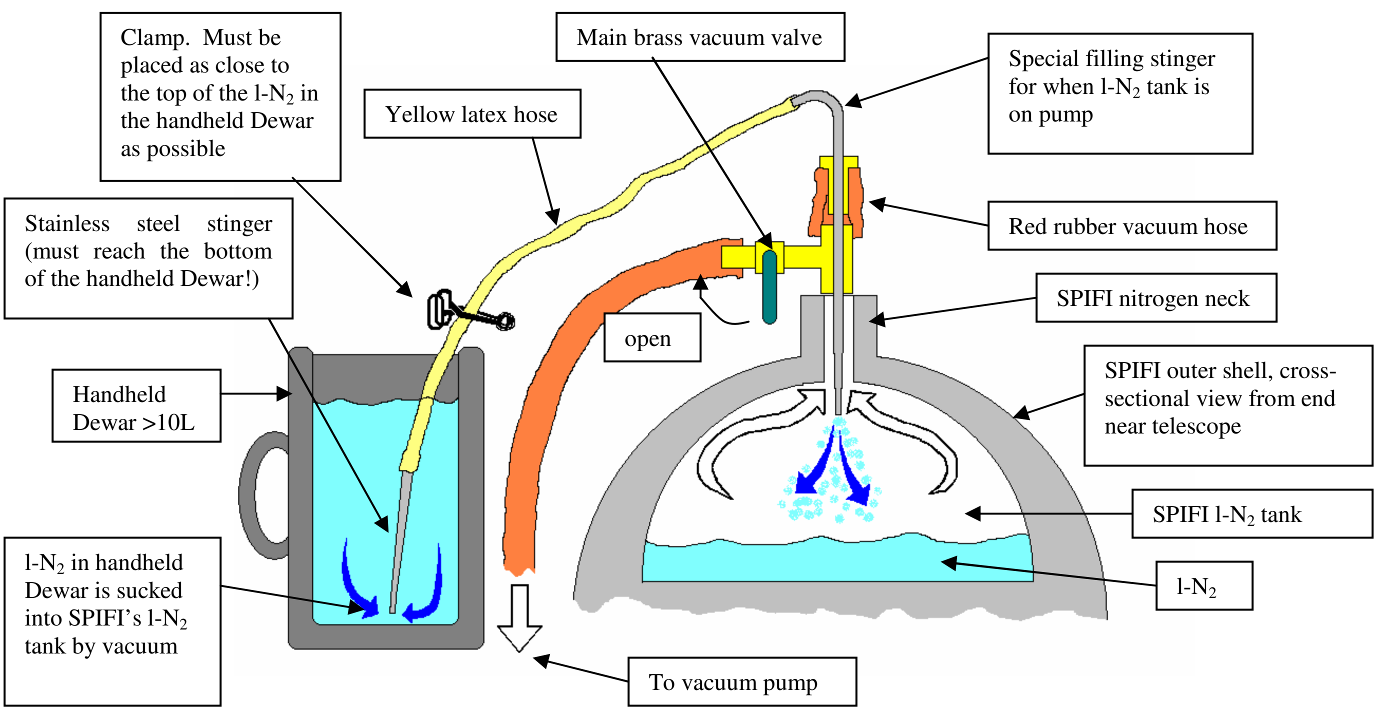


Figure 12: Special Pump and Stinger Assembly for Pumping on SPIFI's l-N_2

If SPIFI's l-N_2 tank is being pumped on, the vacuum hose and special stinger assembly should already be connected to SPIFI's nitrogen neck and the main vacuum valve on the neck should be open. Also, the yellow latex hose should be clamped off near the end before the stainless steel stinger (of course: otherwise the vacuum would be sucking on the atmosphere!).

1. Fill a handheld Dewar with *more than* 10L of l-N_2. A wide-top Dewar is preferred. If the Dewar has a narrow neck, be sure to arrange things so that the yellow latex hose and stainless steel stinger can be removed from the Dewar quickly while still frozen, in case the handheld Dewar runs out of l-N_2.
2. Close the main brass vacuum valve on the SPIFI nitrogen neck.
3. Place the stainless steel stinger at the end of the yellow latex hose into the l-N_2 in the handheld Dewar. The end of the stinger *must* be at the bottom of the Dewar. Also, if the Dewar has a narrow neck, make sure the yellow hose and stinger are inserted straight down into the Dewar without kinks, so that you can get the Dewar out from under them quickly if the l-N_2 runs out.
4. Open the clamp on the latex hose and hold it open until the yellow latex hose is frozen stiff, and then release the clamp and replace it on the hose (this way, when the hose thaws again the clamp will automatically seal it off). *We aren't sure if there are any of these types of clamps at the South Pole, so you may have to find or invent something that will work here. It needs to be strong enough to clamp off the hose tightly but not so tight that it causes damage.*
5. At this point SPIFI will simply "drink till she's full," meaning that the vacuum in SPIFI's l-N_2 tank will suck l-N_2 out of the handheld Dewar until the tank is full. When the tank is full, SPIFI will simply stop drinking because the vacuum in SPIFI will have been replaced by l-N_2. **Make sure the end of the stainless steel stinger is all the way at the bottom of the handheld Dewar while SPIFI drinks. Never let SPIFI suck on the atmosphere, as this will cause an ice plug to form!**
6. If you happen to run out of l-N_2 in the handheld Dewar while SPIFI is drinking, quickly remove the Dewar and place a rubber stopper (size 0) in the end of the stainless steel stinger to plug the vacuum (some of these stoppers should already be in the enclosure, or else in the SPIFI crates in the AST/RO Annex). Refill the handheld Dewar while the yellow latex hose thaws. Once the hose is flexible, re-clamp it near the end with the stainless steel stinger. Remove the rubber stopper, and follow steps 1-4 again.
7. Once SPIFI stops drinking (you will see the flow stop through the translucent yellow latex hose, after rubbing the frost off the outside), leave the end of the stainless steel stinger immersed in the l-N_2 of the handheld Dewar while the yellow latex hose thaws. When the hose has thawed enough, the clamp should seal off the hose again.
8. Remove the handheld Dewar and make sure the clamp is secured near the end of the yellow latex hose near the stainless steel stinger.
9. **Slowly** open the main vacuum valve on the SPIFI nitrogen neck. (Take at least five minutes to completely open this valve so that you don't put too much stress on the pump. You probably won't be able to hear the pump because it is downstairs, so use your best judgment.)

ADR Helium

The ADR's l-^{4}He tank needs to filled once every day. The capacity of the tank is 5L, but the transfer usually takes between 8-10L depending on the transfer tube used. The level of l-^{4}He in the tank cannot be measured because the neck of the tank is horizontal.

1. In the receiver room, open the ^{4}He gas cylinder (make sure you don't accidentally hook up the N_2 gas) and adjust the regulator so that about 5 to 10 psi are going to the roof through the clear Teflon tube.
2. Close the main pump valve **(16)** on the pump manifold on the right-hand wall of the pillbox. This is the large black-handled valve.

3. Attach the ^{4}He gas line (clear Teflon tube which comes up from the receiver room) to the gas inlet nipple **(18)** on the manifold. You will need to use the small brass/yellow tubing adaptor piece. Make sure that you feel gas coming out of the Teflon tube. (The pressure should be ~ 5-10 psi.)
4. **Slowly** crack the gas inlet valve on this nipple to start backfilling the ADR's l-^{4}He tank with ^{4}He gas. You should see the pressure in the pressure gauge **(17)** start to rise. However, this gauge only goes up to 100 Torr, so you won't be able to monitor the pressure beyond this value. Make sure you do this slowly, so that you don't get an overpressure (above 760 Torr) in the ADR's l-^{4}He tank. **See step 5!**
5. At the same time you are letting ^{4}He gas seep into the l-^{4}He tank, loosen and remove the KF *clamp* on the ADR's l-^{4}He neck **(9)**, **but don't take off the end-cap! (Just the clamp).** This will allow the KF end-cap to pop off of the neck in the case of an overpressure (since you can't monitor pressure above 100 Torr).
6. Once the l-^{4}He tank has reached near atmospheric pressure (or the KF end-cap has popped off), remove the end cap and shut off the gas inlet nipple valve.
7. You can now start filling with l-^{4}He using a standard l-^{4}He transfer tube. Make sure that liquid is flowing from the end of the transfer tube's stinger before inserting it into the ADR, or the "warm" ^{4}He gas could blow all of the l-^{4}He out of the l-^{4}He tank. Insert the stinger all the way into the neck until it touches the bottom of the ADR's l-^{4}He tank, and then back it off a half-inch so that the l-^{4}He can flow freely. (Ideally, to minimize l-^{4}He waste, you will have already set up the l-^{4}He Dewar and transfer tube by the time the KF end-cap pops off the neck, so that there is already liquid flowing from the end of the transfer tube's stinger and you can immediately begin filling. However, this involves good timing and requires a bit of practice, especially with only one person).
8. Once the l-^{4}He tank is full, remove the stinger and transfer tube from the l-^{4}He neck and from the l-^{4}He Dewar. Shut off and secure the 100L l-^{4}He Dewar.
9. Crack the main valve of the pump manifold *slightly* to create a suction. Replace the KF end-cap on the l-^{4}He neck and make sure it is securely suctioned onto the flange. The O-ring of the KF cap should be clean and slightly greased with vacuum grease
10. Replace the KF clamp on this end-cap. Make sure it is oriented so that the red vacuum-hose cap of the stickstoff is not blocked.
11. Slowly reopen the main valve on the vacuum manifold. (Take at least five minutes to completely open this valve so as to minimize stress on the pump. You won't be able to listen to the pump because it is downstairs, so use your best judgement). You should eventually see the pressure drop on the pressure gauge, once it gets below 100 Torr. The needle may oscillate wildly. This is normal. Sometimes you can dampen these oscillations by opening or closing the valve a bit. The oscillations usually dampen out on their own once the pressure gets below about 30 Torr. After some time (about ½ hour or so) the pressure should get below 10 Torr. Eventually you want ~3 Torr.
12. **Don't forget to shut off the ^{4}He gas downstairs in the receiver room when you are finished!**

SPIFI Helium

SPIFI's l-^{4}He tank can go a *maximum* of seven days between fills, assuming that everything else stayed cold and the l-N_2 tank never ran out. Therefore, after an initial fill, you should check the level of l-^{4}He in SPIFI's l-^{4}He tank after about three days, and then check it just about everyday thereafter. Basically, you should develop a sense of the rate at which the l-^{4}He is boiling off in the tank, and check the level when you think it is getting low. Use a thumper to check the level, and use the chart in *Appendix A* on page 64 (Table 7) to convert the height of l-^{4}He in the tank to the volume. Each time you check the level in the tank, record the level and the time at which you checked it in the SPIFI notebook.

The capacity of the tank is 65L, but it always takes about 100L to fill. Therefore, to minimize loss of l-^{4}He, you should **always start with a full 100L Dewar of l-^{4}He before filling SPIFI's l-^{4}He tank**. The reason for this is that if you run out of l-^{4}He in the 100L Dewar while filling you may not realize it immediately, and you will be injecting warm air into SPIFI's l-^{4}He tank, thereby blowing out all the l-^{4}He that was in the tank to begin with, and any you may have just filled. If you must begin the fill with a partially full 100L capacity Dewar, keep a close eye on the pressure in the Dewar. When it starts to get low, remove the stinger from the SPIFI l-^{4}He tank frequently to make sure it is still blowing out liquid.

1. Check the level of l-^{4}He in the tank before filling and record this value and the time in the SPIFI notebook.
2. Place a *full* 100L l-^{4}He Dewar on the hand-crank-lift dolly. Crank the dolly up to a height which allows the transfer tube to reach the hatch to SPIFI's helium neck, but not so high up that you can't get the transfer tube in under the baby-buggy-cover.
3. Once the stinger of the transfer tube is squirting out liquid only (or else you may blow all the l-^{4}He out of the SPIFI l-^{4}He tank with "warm" helium gas), fill SPIFI's l-^{4}He tank as you would in any normal l-^{4}He fill (i.e. 4-5 psi in the 100L Dewar).
4. Record in the SPIFI notebook the time of the fill, how long it took to fill, the level of l-^{4}He in the tank before and after filling, and estimate (if you can) how many liters of l-^{4}He were used.

Cycling

The ADR **(8)**, or adiabatic demagnetization refrigerator, is used to cool our bolometer detectors to approximately 60mK, which is necessary in order to achieve high sensitivity in the detectors. However, the ADR alone cannot support the heat load which comes in from the ~1.5K pumped l-^{4}He surfaces which surround it, and so we use a ~300mK ^{3}He fridge system as a thermal guard between the 1.5K and 60mK stages. Because the ADR needs the ^{3}He guard, you must cycle the two systems (ADR and ^{3}He fridge) at the same time in a synergistic manner. The hold time of the ADR is limited by the hold time of the ^{3}He fridge, which is approximately 40 hours. During and between this 40 hour hold-time you will have to keep all the cryogenic tanks filled (see *Maintenance Filling* on page 32 above). Below you will find explanations of how the ADR and ^{3}He systems work, followed by step-by-step instructions to guide you through the cycling process.

Understanding Magnetic Cooling

The functioning of the ADR is explained below in the following manner: in the left-hand column is a description of the general theory of magnetic cooling; in the right-hand column is an explanation of the specifics of our system which correspond to the general theory. Refer to Figure 13, Figure 14, and Table 3 on page 40 below while reading over the explanations.

General Magnetic Cooling Theory	Correspondence in Our System
ADR's are able to achieve low temperatures by adiabatically demagnetizing a paramagnetic salt. In a paramagnetic solid (such as a crystalline salt lattice) the basic atomic unit has unpaired electrons, and thus contains what are referred to as paramagnetic ions. Around 1-2K, and in the absence of an externally applied magnetic field, the interaction energy of these ions with their crystalline environment (the salt lattice) is much less than the average thermal energy kT. Therefore, each ion is relatively free and a randomly oriented system of dipoles results, with negligible net magnetism of the salt.	Our salt pill is a 230g cylindrical pill of $FeNH_4(SO_4) \cdot 12H_2O$, or ferric ammonium aluminum, or FAA. Gold wires are threaded through the pill and thermally couple the pill to the detector array. FAA can reach temperatures down to 50mK through adiabatic demagnetization.
If the salt is kept at a constant temperature in contact with a cold reservoir (around 1-2K), and an external magnetic field is slowly applied, then the paramagnetic ions in the salt will align themselves with the external field. Because this is done isothermally (at some specific temperature in the range of 1-2K) the temperature of the salt cannot increase. Instead, the heat of magnetization, ΔQ, is dumped into the cold reservoir. Therefore the entropy, S, of the salt decreases (recall $dS=dQ/T$ by definition).	Our cold reservoir is the pumped l-^{4}He tank, which is ~1.5-1.8K. The salt pill is kept in contact with this tank during magnetization by closing the pill heat switch **(21)**, and in practice the pill does actually show some increase in temperature as can be monitored on its GRT. The magnetic field is supplied by a superconducting solenoid coil (also at pumped l-^{4}He tank temperature) which coaxially surrounds the salt pill. We use the magnet power supply **(23)** and the magnet control box **(22)** to supply 20.2A of current to the solenoid (via the magnet leads **(28)**) at the "moderate" ramp-up rate of 1A/s. At 20.2A, the solenoid has an internal magnetic field of ~4T.
Once the external magnet field has been increased to its maximum value, it should be left at that value until all but a very small percentage of the paramagnetic ions in the salt are aligned with the field. The entropy continues to decrease to some limiting value which	When the solenoid achieves a field of ~4T (at 20.2A) we close a persistent switch **(24)** (which was kept open up to this point). The persistent switch is a superconducting switch that acts as a "short" between the two magnet leads **(28)**. When the persistent switch is

depends on the maximum magnetic field.	closed, it is superconducting. The solenoid is, of course, also superconducting. Therefore, after closing the persistence switch we can take current out of the (non-superconducting) leads at a fast rate (10A/s) but still leave 20.2A flowing around the superconducting solenoid and through the persistent switch short and around again and again. The current path is superconducting and hence a 4T field is maintained with no dissipation. We must leave the solenoid magnetized for about 30 minutes before continuing.
Next, adiabatically isolate the salt from the cold tank, and remove the magnetic field quasi-statically (this is the *adiabatic demagnetization*). Because this is done adiabatically ($\Delta Q=0$) and quasi-statically, the entropy must remain constant ($dS=dQ/T$). In addition, it can be calculated that the entropy of a paramagnetic salt is dependent on the independent variables B and T by a ratio of $(B^2+b^2)^{1/2}/T$, where b is the interaction field between the ions, and is negligible except at very low temperatures. Therefore, during adiabatic demagnetization, with S=constant, one can see that $B_i/T_i \approx B_f/T_f$. So as B is decreased, T must decreased. (But b prevents T_f from reaching 0K!)	Open the pill heat switch to thermally decouple the salt pill from the pumped l-^{4}He tank. Put 20.2A of current back in the magnet leads (quickly, at 10A/s). The purpose of this is to eliminate any current jump between the leads and the solenoid, so that no power is dumped in the ADR when we pull the 20.2A of current out of the solenoid through the magnet leads Open the persistent switch. This causes the closed circuit through the persistent switch and around the solenoid to be interrupted. The new current path flows in from the magnet controller through the positive magnet lead, around the solenoid, and out to the magnet controller ground through the negative magnet lead. Take the current out of the leads very slowly (0.1A/s) to demagnetize the solenoid quasi-statically. It takes about 30 minutes until the current on the magnet power supply is at 0A. Turn off the persistent switch heater and then turn off the magnet control box and the magnet power supply at the same time. Then disconnect the magnet leads from the ADR. With another ½ hour the salt pill will be near 60mK.
As the salt absorbs heat from its surroundings, the temperature and entropy rise iso-magnetically (I don‘t know if that’s a word, but I mean with B=constant=0) until the salt has reached its initial temperature (somewhere between 1-2K). The time constant depends on the heat load on the salt, and on the physical properties of the salt itself.	The heat load to our salt pill is dominated by two sources which each contribute about 20-30nW: conduction from 300mK through array wiring, and 1.5K radiation. Therefore we have a total heat load of about 50nW which limits the hold time of 60mK in the salt pill to 100 hours. However, our whole system is limited by the ^{3}He 300mK stage, which acts as a thermal conduction shield between the 1.5K stage and the 60mK stage. The hold time of the ^{3}He system is only about 40 hours. See *Understanding the* 3He Fridge below.

Figure 13: Electrical Schematic for Magnetizing and Demagnetizing the Solenoid

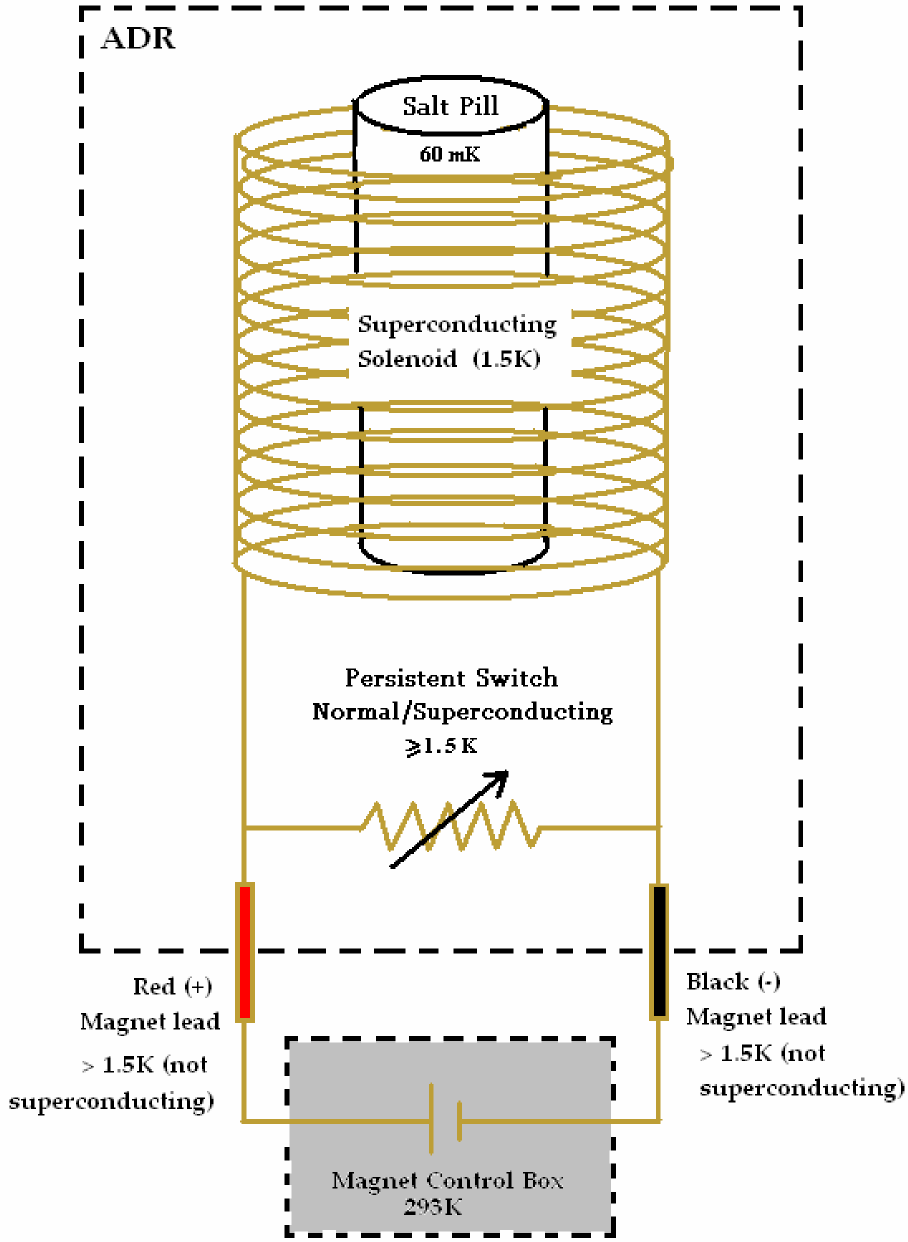
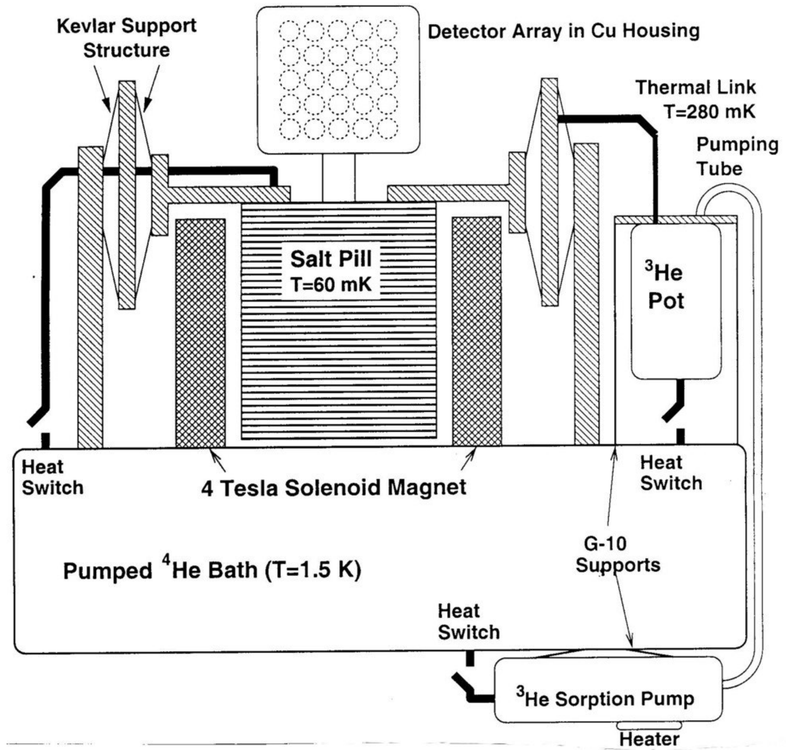


Table 3: Persistent Switch Settings

Persistent Switch Settings				
Key Position	Nominal Position	Temperature Status	State	Switch position
key vertical (90° counter-clockwise)	"OFF"	Switch at 1.5K, not being heated	superconducting	closed
key horizontal (90° clockwise)	"ON"	Switch being heated >1.5K	Normal	open

Figure 14: Mechanical and Thermal Schematic of the ADR and 3He Fridge



Understanding the 3He Fridge

The ^{3}He fridge can achieve a temperature of 280mK for a hold time of approximately 40h. It provides the necessary thermal shield between our pumped l-^{4}He tank (and all the surfaces inside the ADR Dewar which are connected to it) at ~1.5K, and the salt pill and detector array at 60mK. The primary heat load seen by the ^{3}He fridge is conduction from the 1.5K stage through the fiberglass G-10 which mechanically supports the fridge (see Figure 14 above). This load is ~75mW and it vaporizes all of the l-^{3}He from the pot in 40h.

The operation of the ^{3}He fridge is much simpler than that of the ADR. The key components of the ^{3}He fridge---the pump, pot, pumping tube, and heat switches---are shown in the right side of Figure 14 above. The entire system is closed-cycle: it is a sealed system which contains a fixed amount of ^{3}He at low pressure and exchanges no substances with the outside. It has no moving parts (other than the manually adjusted pump and pot heat switches **(20)** & **(19)**). The construction consists of the pumping chamber being connected to the pot chamber via the pumping tube. That's about it. The pump is not a mechanical pump, but rather a piece of charcoal sealed inside the pumping chamber. When the charcoal is cooled to low temperatures (~1.5K) its enormous surface area adsorbs ^{3}He gas. In this way it "pumps" on the atmosphere inside the closed system. Furthermore, the pressure inside the fridge is such that ^{3}He goes through the liquid/gas phase transition at ~2-2.5K. This allows the entire fridge to be cycled simply by heating and cooling the pot and pump: they can both be cooled down to 1.5K by thermally connecting them to the pumped l-^{4}He tank via the pot and pump heat switches, and the pump can be heated up to 50K via a resistive heater which is thermally strapped to it.

The process for cooling to 280mK is as follows:

- First, the pump heat switch is closed (the pot heat switch can be either open or closed, it doesn't matter). This cools the charcoal in the pump to ~1.5K, causing it to adsorb most of the ^{3}He in the system. I don't know for sure how long this process takes, but this is the state that is achieved at the end of the hold time of a cycle. Therefore, when you are ready to re-cycle, the ^{3}He is already all adsorbed in the charcoal.
- Next, the pot heat switch is closed and the pump heat switch is opened.
- The pump is then heated to about 50K. This causes all the ^{3}He to evaporate out of the charcoal. Because the pot heat switch is closed, the pot is at 1.5K. Therefore the evaporated ^{3}He will condense out into the pot. It takes about four hours for the ^{3}He to be forced out of the charcoal and for the heat of vaporization to be removed from the pot through the heat switch to the l-^{4}He tank.
- Once most of the ^{3}He has condensed in the pot, stop heating the pump. Now the heat switches are reversed once again: close the pump and open the pot. This causes the charcoal to once again cool to 1.5K and start "pumping" on the ^{3}He atmosphere above the l-^{3}He in the pot. As the pressure in the pot decreases, so does the temperature. It takes about ½ hour from this point for the pot to reach ~280mK.
- After 40h, the pot will warm back up to 1.5K, and you will have to start the process over again.

When the instrument is at room temperature, the ^{3}He gas inside the fridge collects in an external storage tank with a volume of ~2L. At room temperature the gas is stored there under a pressure of about three atmospheres. This storage tank is the long, cylindrical, chrome-plated structure attached to the ADR's outer shell. When SPIFI is mounted in the enclosure on AST/RO, this is found on the upper right side of the ADR (see Figure 5 on page 26 above). There are two green-colored Swagelok valves connected to this tank. The first valve---the valve closest to the end of the ADR with the l-^{4}He and l-N^2 filling necks (closest to the pillbox doors)---connects the storage tank to the rest of the closed fridge system. This valve should be opened when the ADR is at room temperature and not being used. It should be closed during cool-down when you start pumping on the ADR l-^{4}He tank, and left closed as long as everything is cold. The second further back Swagelok valve opens the storage tank to the atmosphere. **Never touch this valve, or you will release all our ^{3}He to the atmosphere!**

Step-By-Step Cycling of the ADR and 3He Fridge

Below is a step-by-step procedure for cycling the ADR and ^{3}He Fridge. Notice that the cycling of the two systems is an intermixed process. To help you understand the reasoning behind each step below, a right-hand column with "Explanations" has been included. You may also wish to consult Figure 13, Figure 14, and Table 3 above while going through the cycling to get a better picture of what's going on inside the ADR.

Step	Action	Explanation
1.	Put the battery box on the charger while you cycle. (See *The Battery Box* on page 57 below for charging instructions.)	We only have one working batter box, and it will need to be charged everyday while observing. Since observing can't take place during cycling, this is an ideal time to charge the battery box.
2.	Top off the ADR l-^{4}He **(9)** and ADR l-N_2 **(10)** tanks (see *Maintenance Filling* on page 32 above).	This is to make sure you don't boil off all your liquid cryogens, since the boil-off rate will increase during cycling due to the ^{3}He pump heater, the persistent switch heater, the heat of magnetization, the latent heat of condensation of ^{3}He, and various other sources of waste heat from electrical currents and from work being done on the system.
3.	Open the pump heat switch **(20)** and close the pot heat switch **(19)**.	We close the pot switch so that the pot cools down to 1.5K. We open the pump switch because we will soon start heating the pump to a temperature higher than 2-2.5K in order to evaporate all the l-^{3}He which is soaked into the charcoal in the pump. Then the gaseous ^{3}He will flow from the pump to the pot, and condense out in the pot (which is at 1.5K).
4.	Close the pill heat switch **(21)**.	Makes sure the pill stays at 1.5K during the cycling process. This is necessary because the ADR cooling process requires that we magnetize the salt pill isothermally.
5.	Connect the housekeeping cable **(27)** to the ADR	Connects the electrical inputs for the ^{3}He pump heater, the persistent switch, and the GRT read-outs.
6.	Put the ADR l-^{4}He back on the pump.	Gets your l-^{4}He surface cold. It must eventually drop below the boiling point of l-^{3}He in the ^{3}He fridge system. This point depends on the pressure inside the ^{3}He fridge system, but is probably around 2-2.5K (which is easily achieved by the ADR l-^{4}He tank when it gets down below to 5-10 Torr). Note that all three heat switches (pill, pot, and pump) thermally connect to this surface when closed.
7.	Turn on the ^{3}He pump heater **(25)** and set it to 5 volts. This is the small green power supply located in the bottom left corner of the pillbox, under the ADR.	Heats the charcoal in the pump to a temperature above 2-2.5K (and up as high as 50K). This causes the ^{3}He to boil out of the charcoal since its boiling point at the pressures inside the fridge is ~2-2.5K. The ^{3}He then flows to the pot (which is at 1.5K because the pot heat switch is closed) and condenses out there.
8.	Check that the resistance (of the ^{3}He pump) is going down on the multi-meter **(26)** which is connected to the ^{3}He pump heater (via the blue switch board **(56)**).	This is to make sure the pump is heating up properly
9.	Once the resistance is equal to 2kΩ (which takes about 30-40 minutes), turn the ^{3}He pump heater	2kΩ is the desired temperature (or corresponding resistance, if you like) at which we would like to heat the

	down to 2 volts.	pump for the next 4 hours. We start with 5V just to speed up the process of getting the pump warmed up to 2kΩ. However, if you leave the heater on 5V too long and let the resistance drop much below 2kΩ, then you will have to wait longer than 4 hours in step 21 below. (This is because you will start overheating the ^{3}He gas which flows to the pot, and it will take longer to condense in the pot. Your l-^{4}He boil off will also increase.)
10.	Plug the magnet leads **(28)** into the ADR. **Match red to red** (tape on ADR) **and black to black** (paint on ADR). See Figure 16 below. Make sure the magnet leads don't make a short.	Connects the magnet leads from the magnet control box **(22)** to the ADR. We will use these leads to get current into (and out of) the solenoid coil which surrounds the salt pill. (And hence magnetize (and demagnetize) the salt pill.) See Figure 13 above.
11.	Check that the current direction on the magnet controller **(22)** is set to the down position (see Figure 15 below).	Therefore when you turn on the controller the magnet won't start ramping up automatically. It is important that you don't ramp up until the persistent switch is opened (step 13 below).
12.	Turn on both the magnet controller **(22)** and magnet power supply **(23)** at the same time (see Figure 15 below). Wait a minute or so until you can hear the fans in both boxes start up and running smoothly.	The magnet controller and power supply will be used to activate the persistent switch and to magnetize and demagnetize the salt pill.
13.	Turn the persistent switch heater **(24)** on the magnet controller to on by turning the key 90° clockwise (see Figure 15 and below and Table 3 above). The green indicator light should come on.	The persistent switch will open when heated (i.e. it will go normal and develop a resistance). This will block the "short" between the magnet leads.
14.	Wait 2 minutes.	Give the persistent switch time to heat up and open.
15.	Set the current rate to 1 amp/sec and flip the current direction to the up position on the magnet controller. The controller and power supply should show increasing current on their displays.	Start ramping up the magnet by putting current into the leads at a rate of 1 amp/sec. Because the persistent switch is open, the current will flow from the positive lead, through the solenoid coil, and back out through the negative lead to ground in the magnet controller.
16.	Once the current has peaked at 20.2 amps (about 1-2 minutes), turn the persistent switch heater off. The green indicator light should go off and the current limit LED should light up.	The maximum current we want to leave in the solenoid is 20.2 amps. By turning the persistent switch heater off, the switch will go superconducting and close. This will provide a short between the magnet leads. However, because the solenoid and the persistent switch are superconducting, and the "warm" leads are not, all of the 20.2 amps of current will take the path of least resistance, and will flow in a continuous loop around the solenoid.
17.	Wait 2 minutes.	Give the persistent switch time to go superconducting.
18.	Take the current out of the leads by flipping the current direction to down. If the system is behaving well (i.e. the current is dropping) at the ramp down rate of 1 amp/sec, you can increase the rate to 10 amps/sec.	There is still current in the leads (as well as the solenoid and persistent switch "short") because of the potential difference created by the magnet controller between its leads. Here we can just take the current out of the leads by ramping down. Note that because the solenoid coil and the persistent switch "short" are superconducting, a current of 20.2 amps will be left flowing around the solenoid. This creates a stable central magnetic field of approximately 4T, which will magnetize the salt pill isothermally (since the pill heat switch is closed, the

		salt pill will be held at 1.5K). To completely magnetize the salt pill, we must wait for the paramagnetic ions within the salt to align with the 4T field. This takes about 30 minutes.
19.	Once the magnet controller reads 0.00 amps (or 0.01 amps), turn off both the magnet controller and magnet power supply at the same time.	The superconducting solenoid magnet is activated, and we don't need a current source anymore.
20.	Check again that the pump heater has stabilized around 2kΩ. You are done with the first half of the cycle. Go have a coffee.	Everyone needs a cup of Joe.
21.	Wait 4 hours for ^{3}He to condense in pot.	When heating the pump at 2kΩ, it will take approximately 4hrs for all of the ^{3}He to completely evaporate from the charcoal in the pump and to condense out in the pot. Note that the salt pill will be completely magnetized after only a half hour. Don't worry about this. You can leave the solenoid magnetized for the entire 4hrs without any negative effects while you wait for the ^{3}He to condense. Note that the limiting process in the time it takes to cycle is the condensation of ^{3}He in the pot (4hrs).
22.	Turn off the ^{3}He pump heater (small green power supply)	At this point, all of the ^{3}He should have boiled off from the charcoal in the pump and condensed in the pot.
23.	Open the pot heat switch and close the pump heat switch (you might try to do this at the same time).	Opening the pot switch will disconnect the pot from the 1.5K surface and thermally isolate the pot. Closing the pump head switch will connect the charcoal in the pump to the 1.5K surface. As the charcoal cools, its large surface area will begin to adsorb ^{3}He gas, and it will therefore act as a pump on the atmosphere above the l-^{3}He in the pot. Pumping on the l-^{3}He in the pot will lower the temperature of the pot to about 280mK.
24.	Open the pill heat switch.	We have isothermally magnetized the salt pill, and it is now time to begin an adiabatic demagnetization of the pill. Opening the pill heat switch will thermally (adiabatically) isolate the pill.
25.	Make sure the current direction on the magnet controller is set to down and turn on the magnet power supply and the magnet controller at the same time. Wait a minute or so until the fans in the boxes start up and are running smoothly.	We will need to put current in the leads and use the persistent switch in order to demagnetize the salt pill.
26.	Put current on the leads by flipping the current direction to up. Set the rate to 10 amps/sec.	There are 20.2A of current flowing around the superconducting solenoid, but no current in the leads. Therefore, if we were to open the persistent switch without putting current into the leads first, then the 20.2A would be quickly forced out of the solenoid through the leads and to ground in the magnet controller. This would cause the power stored in the 4T magnetic field to be dumped into the pill and the ADR in the form of heat energy, thus causing the temperature of the whole system to rise drastically. We would then have to refill the ADR's liquid cryogen tanks and re-cycle. However, if we first put 20.2A of current in the leads and then open the persistent switch, we can quasi-statically

		demagnetize the solenoid by ramping down the current very slowly.
27.	Once the system is current limited (20.2 amps), turn on the persistence switch heater.	The leads now have the same current as is flowing around the superconducting solenoid (20.2A), and there will be no current jump (and hence no power dump) when we open the persistent switch.
28.	Wait 2 minutes.	Wait for the persistent switch to go normal (open).
29.	Set current rate to 0.1 amps/sec, and flip current direction to down.	We now demagnetize the solenoid quasi-statically by taking current out of the leads at a very slow rate (0.1 amps/sec).
30.	Wait about ½ hour.	Wait for the current to ramp-down.
31.	Once the magnet controller reads 0.00 amps (or 0.01 amps), turn off the persistence switch heater. Then turn off both the magnet controller and magnet power supply at the same time. Remove the magnet leads from the ADR.	We don't need them anymore. The magnetic field has now been removed from the salt pill. Within a half-hour, the paramagnetic ions in the salt will start to loose their alignment. Because the salt pill is thermally isolated (the pill heat switch is open), this demagnetization will occur adiabatically, and hence the pill will be forced to very low temperatures (60mK).
32.	Top off the ADR l-^{4}He and ADR l-N_2 tanks.	Gotta keep the cryo-tanks happy.
33.	After about ½ hour, the pill GRT should be in the 700Ω-5kΩ range, and the pot GRT should be around 120Ω (see *Temperature Monitoring* on page 29 above). You are now cold enough to observe.	By now, most of the paramagnetic ions in the salt have lost their alignment. Through this adiabatic demagnetization the salt will equilibrate at ~60mK after about one half -hour.
34.	Don't forget to take the housekeeping cable out of the ADR.	This cable adds noise and heat, and is no longer necessary, except when you want to check the GRTs.
	DONE!	

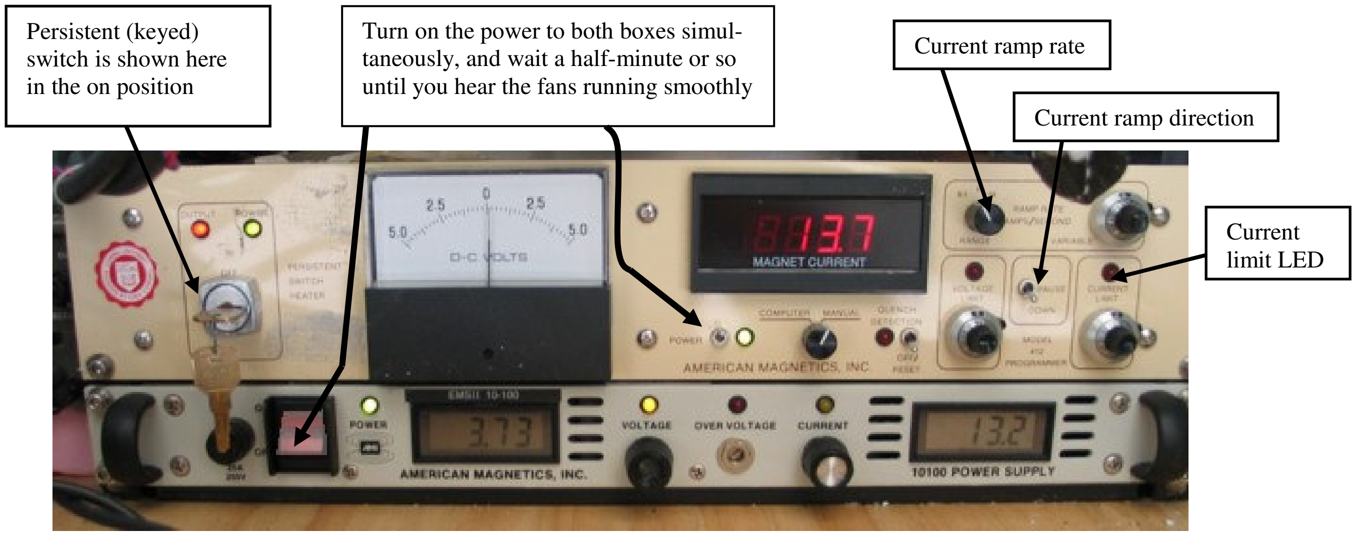


Figure 15: Magnet Controller (top) and Magnet Power Supply (bottom)

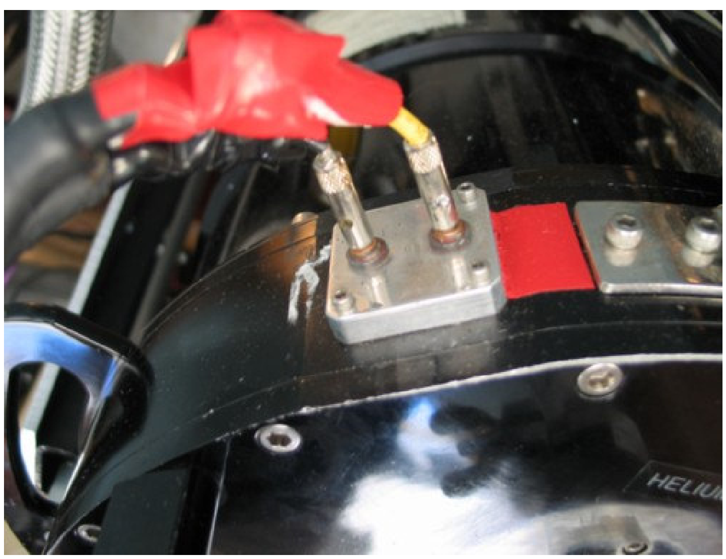


Figure 16: Magnet leads plugged into the ADR

Calibration Unit

Basic description

The calibration unit is the aluminum box mounted to the front of SPIFI on the telescope side where the beam first enters SPIFI from the telescope (see Figure 17 below). It includes the chopping blade, a DC motor for running the chopping blade, a blackbody, a gas cell, a stepper motor for moving the gas cell and blackbody into and out of the beam path, and various photometric and thermometric sensors. The electronics control box **(46)** for the calibration unit is located at the top of the electronics rack on the Fabry side of SPIFI, in the enclosure. There is a single grey cable which connects the control box with the calibration box. There is also a grey cable which runs from the control box through the cable-wrap down into the telescope control room, and which connects to “The Remote.” “The Remote” is a remote control device which allows one to operate the chopper motor without going outside. Additionally, there is a BNC cable running from the control box to Fabry which allows Fabry to read the chopping frequency. Finally, the two serial cables on the left side of the control box are part of a serial cable daisy-chain which allows Fabry to communicate with the stepper motor. (Note: if there is ever a need to use the remote while on the roof of AST/RO, there is an additional remote control cable located on the floor of the Fabry side of the enclosure to the left of the electronics rack, and you can simply disconnect the remote in the telescope control room and take it up on the roof and use the extra cable up there).

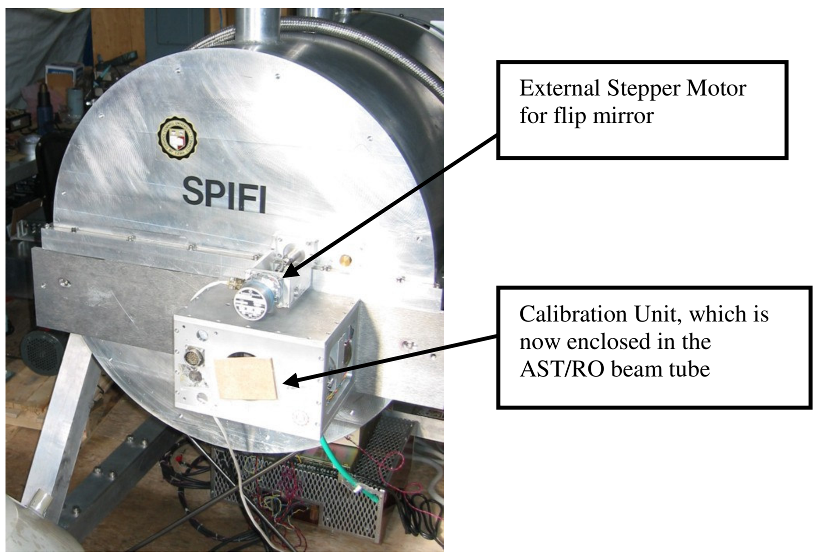


Figure 17: A view of the end of SPIFI opposite the ADR, before SPIFI went into the enclosure

Figure 18: The electronic control box for the SPIFI calibration unit

Chopping

1. The control box should already be turned on (all the electronics should have been turned on to help heat the enclosure after SPIFI was first cooled down from room temperature, provided that the temperature in the enclosure was above 0°C to begin with). If the control box isn't turned on, then in the following order turn on the main power, then turn on the indexer, then the driver, and finally the Omega temperature control unit (these switches should run from left to right across the box). Only turn it on if the enclosure temperature is above 0°C.
2. Using "The Remote," located in the telescope control room, turn the chopping blade on/off switch to on. The red and green LEDs to the right of this switch should start flashing, indicating that the blade is rotating. The red and green LEDs on the remote are directly connected to two photo-sensors, which are located on different sides of the beam path in the calibration box itself. Each LED on the remote lights precisely when the blade passes through its corresponding photo-sensor in the calibration box. If the LEDs do not immediately start flashing, this means that the speed of the blade is set too low for the blade to have sufficient start-up inertia. If this is the case, the blade can be started by simply turning up the blade speed using the pot in the middle of the remote.
3. Once the blade is running, adjust the pot on the remote to achieve the desired chopping frequency. We usually use 8.2 Hz, which corresponds to a setting of "9.5" on the remote's pot. A chart for comparing chopping frequencies to pot settings is located on the back of the remote. (If needed, one can check the chopping frequency directly by connecting a BNC cable to the top of the remote).
4. To stop the chopping blade, simply move the switch on the remote to the off position. There is a logic circuit in the control box which should stop the blade only when the blade is completely out of the beam path. When the blade has been stopped out of the beam path, both the red and green LEDs on the remote should be off. (If either or both of these two LEDs are still lit, it means that circuit has failed to stop the blade out of the beam path. If the LEDs continue to flash, the circuit has failed to stop the blade at all. If this is the case, the blade can be stopped by simply turning off the main power to the control box (see step 5 below). The blade must then be moved out of the beam path by reaching into the calibration box from the telescope hatch door and moving the blade physically with a pen, for instance. Be careful not to touch the window on SPIFI!) Always stop the chopping blade when you are leaving AST/RO or when you won't be using it for a while.
5. You can leave the control box and all its components turned on to help heat the enclosure. However if you need to turn off the control box for whatever reason, first make sure that the temperature control, the driver, and indexer have been turned off (in that order), and then turn off the main power. It is okay to leave the temperature controller set at a high temperature when you turn it off.

Using the Gas Cell and Blackbody

1. The control box should already be turned on (all the electronics should have been turned on to help heat the enclosure after SPIFI was first cooled down from room temperature, provided that the temperature in the enclosure was above 0°C to begin with). If the control box isn't turned on, then in the following order turn on the main power, then turn on the indexer, then the driver, and finally the Omega temperature control unit (these switches should run from left to right across the box). Only turn it on if the enclosure temperature is above 0°C.
2. The temperature of the blackbody can be set to a constant Celsius temperature by adjusting the up/down small arrow buttons on the Omega temperature control face. We usually leave it set at 80°C. The bottom of the digital display screen indicates the *desired* temperature of the blackbody in green. The top of the digital display screen indicates the *actual* temperature of the blackbody in red. Upon turning on the temperature control unit, you should see the red numbers climb as the blackbody warms up. When the red value finally reaches the green value, the blackbody may continue to heat and the red value may overshoot the green a little. However, the red value should eventually equilibrate about the green value. To momentarily check the ambient temperature near the chopping blade, depress the red "check ambient temperature" button to the left of the temperature controller.

3. The blackbody and gas cell together can be moved into or out of the beam path by typing a command in the Matlab interface on Fabry (via a computer downstairs which is logged on to Fabry). To move the gas cell into the beam path, type Gas_Cell_in. It takes about a minute to complete this command. To move the gas cell out, type Gas_Cell_out. If the gas cell is already out of (or in) the beam path and you type the wrong command, the program will tell you that the gas cell is already out of (or in) the beam path. You can easily check if the gas cell is in or out of the beam path by typing the wrong command into the computer and noting the output, or by looking at the yellow and green LEDs at the bottom of the remote. The yellow LED should light if the gas cell is in the beam path, and the green one should light if the gas cell is out of the beam path.

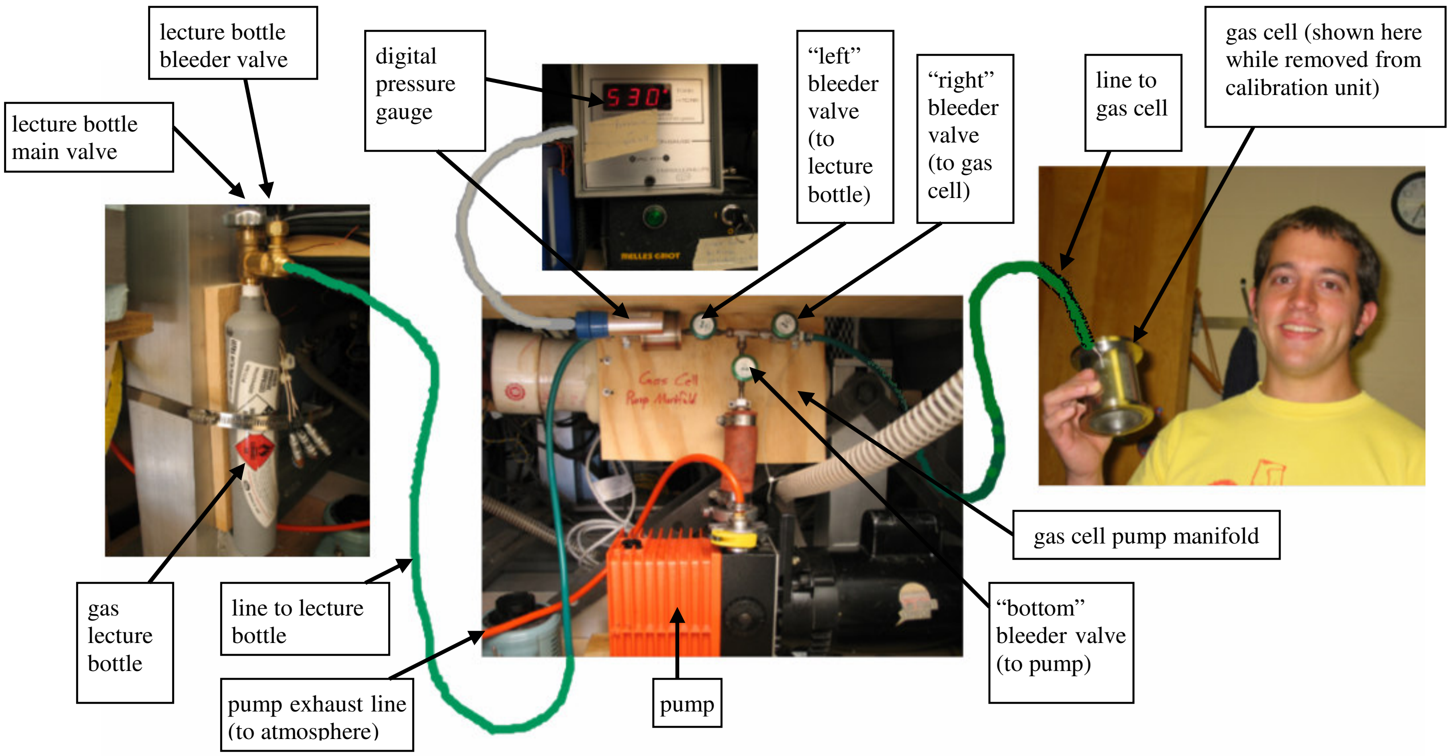


Figure 19: Gas cell manifold setup

4. To fill the gas cell with a gas of choice, first make sure that all three green-colored "bleeder" valves on the gas cell pump manifold **(40)** (located in the enclosure under SPIFI on the battery box side) are open.
5. Close the main valve on the gas lecture bottle **(42)** (as it should already be). See Figure 19 above.
6. *If the main valve on the gas lecture bottle is closed*, open the green-colored bleeder valve on the gas lecture bottle.
7. Turn on the orange pump **(41)** under SPIFI by plugging it in. (If the pump is very cold then you may need to physically disconnect the pump from the gas cell manifold and let it pump on the atmosphere until the oil heats up). The pump should be able to pump-down the manifold, gas cell, and all the connecting lines to about 1-2 Torr if you let it run for several minutes.
8. When all the manifold valves are open and the manifold, gas cell, and connecting lines have been pumped down to 1-2 Torr, close the valve at the bottom of the manifold to close-off the pump.
9. Close the bleeder valve on the gas lecture bottle.
10. **Unplug the pump (it creates vibrations which heat up the detectors).**
11. Put a small "shot" of gas from the lecture bottle into the gas cell. **You must be extremely careful not to put too much gas in or you could blow out the fragile plastic windows of the gas cell!** We suggest the following method for doing this:

   a. Make sure the bleeder valve on the gas lecture bottle is closed. (The main valve on the lecture bottle should also be closed!)
   b. Crack open the main valve on the gas lecture bottle for 1 or 2 seconds and then close it immediately. This allows a “shot” of pressurized gas to fill the small cavity between the lecture bottle’s main valve and the lecture bottle’s bleeder valve. This is our definition of a “shot.”
   c. Now slowly crack open the lecture bottle’s bleeder valve and let the “shot” fill the manifold and the gas cell. Carefully watch the pressure meter to make sure you don’t over-pressurize the gas cell. One shot should fill the manifold and gas cell with about 50 Torr of gas.
   d. Add another shot if you need to.

   The optimal pressure of gas to put in the gas cell depends on the spectral line which you are observing, and typically falls between 50-150 Torr.

12. When you have the desired pressure of gas in the gas cell, close the bleeder valve on the lecture bottle.
13. Close the right-hand bleeder valve (to the gas cell) on the pump manifold.
14. Now the gas cell should be filled with the desired pressure of gas, the blackbody should be heated to the desired temperature, the gas cell and blackbody should be moved into the beam path, and the chopper blade should be running at the desired frequency. If this is the case, then you are ready to take calibration scans. Refer to SPIFI Data Acquisition manual.
15. You can leave the control box and all its components turned on to help heat the enclosure. However if you need to turn off the control box for whatever reason, first make sure that the temperature control, the driver, and the indexer have been turned off (in that order), and then turn off the main power. It is okay to leave the temperature controller set at a high temperature when you turn it off.

Getting a Sync Signal for Fabry

In “Lockin” observing mode---which is the only mode we will be using---the Lockin Tool has to be enabled. I.e., the Lockin Tool GUI should be displayed on the computer you are using to operate SPIFI (refer to the SPIFI Data Acquisition manual for more info). If the Lockin Tool is not already up, select “sync present” in the Data Acquisition Tool GUI.

When carrying out the wavelength calibration (observing the blackbody through the gas cell), the sync signal for lockin detection is provided by the electronic control box **(46)** for the SPIFI calibration unit. In this case a BNC cable must be connected from the data acquisition board in the back of Fabry **(50)** to the sync signal BNC connector on the front of the electronic control box (this connector is labeled “check chopping frequency”, and it can be seen in Figure 20 below).

Figure 20: Sync signal cables on the electronic control box for the calibration unit.

On the other hand, when doing observations of a celestial source (in which case the AST/RO tertiary mirror is used as a chopper), the sync signal is provided by the AST/RO chopper electronics. In this case the white BNC cable shown in Figure 20 above will carry this signal. This cable must now be connected to Fabry. The easiest and by far most convenient way to do this is by unplugging the black BNC cable from the “check chopping frequency” connector on the front of the electronic control box and mating it with the white sync signal cable via a female-female BNC adaptor (mate the two cables which are labeled in Figure 20). Also, you need to make sure the white sync signal cable is actually connected to the AST/RO chopper control electronics in the AST/RO receiver room. Figure 21 shows where the white sync signal cable needs to be plugged in. The black banana-style connector is for grounding purposes.

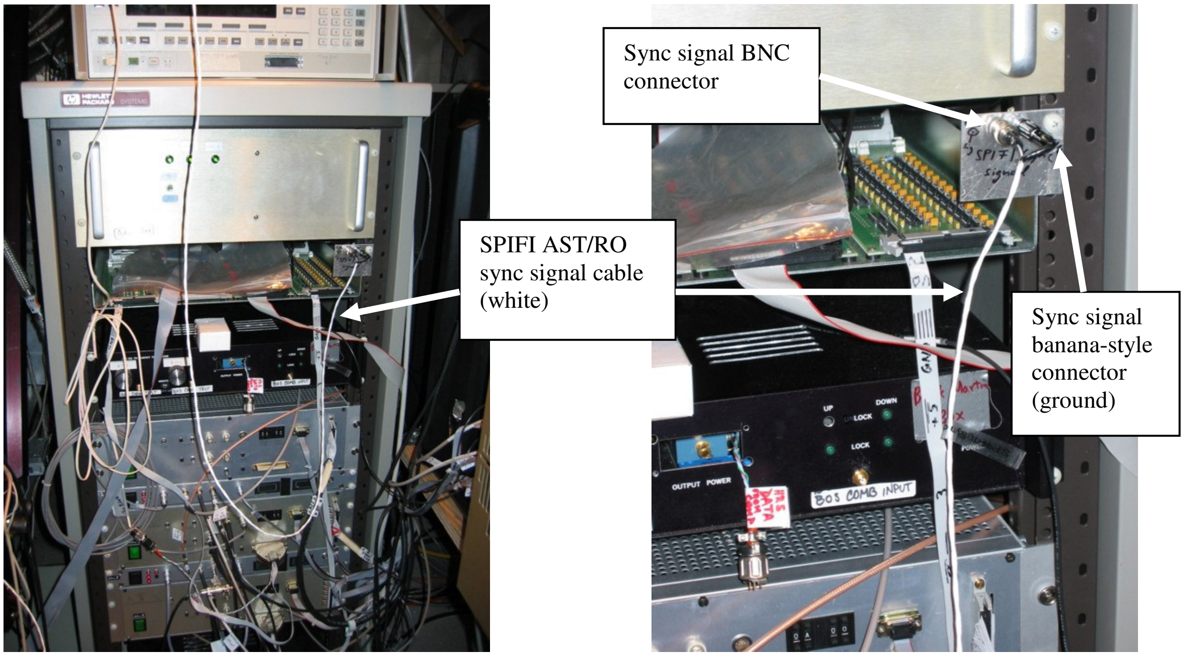


Figure 21: ATS/RO chopper electronics located in reciever room

Note that the phases also need to be adjusted depending on what kind of observation is carried out. See the SPIFI Data Acquistion manual for details.

Parallelizing the Fabry-Perots

In order for our Fabry-Perot interferometers to work, the two plates on each Fabry-Perot must be parallel. This is accomplished by adjusting three ceramic piezoelectric actuators (PZT's) which are positioned equidistantly around the moveable plate of each Fabry-Perot. The PZT's expand by a small precise amount when a high voltage is applied across them. The high voltage is supplied by the two PI power supply boxes **(38)** & **(39)** underneath the SPIFI alignment table inside the battery box side of the enclosure.

This should be done…

- during an initial cool-down, after all four cryogen tanks have been filled with the appropriate amount of l-N_2 and SPIFI is at approximately 77K (see *Cooling SPIFI Down from 293K* page 22 above).
- after an initial cool-down is complete and the temperature and pressure are stable.
- any time you move the HOFPI or LOFPI a large distance (such as when changing orders or wavelengths).
- otherwise about once a day.

How to adjust manually…

(This usually only needs to be done for the HOFPI, but the same procedure also applies to the LOFPI).

1. First you must move the flip mirror into the "laser" (must be pronounced as by Dr. Evil in Austin Powers) beam path. The flip mirror (which is located inside the main SPIFI Dewar) is controlled by a stepper motor, which is attached to SPIFI just above the calibration box (see Figure 17 on page 48 above). The electronics box that controls this motor is located at the very bottom of the electronics rack in the enclosure on the Fabry side of SPIFI. We call this the "SPIFI Motor Box" **(49).** The motor box can operate up to four motors (serial addresses 2-5), but the flip mirror's stepper motor is the only thing connected at the moment (its connected to port "5"). The motor box should already be turned on (all the electronics should have been turned on to help heat the enclosure after SPIFI was first cooled down from room temperature, provided that the temperature in the enclosure was above 0°C to begin with). If it is not already turned on, first turn on the main power switch, and then turn on the power switch located above port "5." But only turn it on if the enclosure temperature is above 0°C.
2. Move the flip mirror into the "laser" beam by typing the command flip_home in the Matlab interface on Fabry (via a computer downstairs which is logged onto Fabry). To move the flip mirror out of the beam path type flip_clear. If the motor box (or Fabry) was not already turned on, you will need to type flip_home first in order to "initialize" the indexer and driver, so that they know where the flip mirror is at.
3. Next you will need to go up to the enclosure and turn on the "laser" power. This is the Melles Griot box **(37)** located in the middle of the shelf under SPIFI on the battery box side. Turn the key to power on the "laser." If you stand up inside the battery box side of the enclosure, you should be able to see a "laser" pattern on the screen **(54)** hanging opposite the "laser" **(36)** on the ADR end of SPIFI (see Figure 22 below). If you don't, then either the flip mirror is not in the beam path, the "laser" is not turned on, or the external "laser" mirror needs adjusted. Or maybe you just need to turn the lights out! Otherwise, it means that something catastrophic happened (i.e. the Fabry-Perot meshes are blown-out).
4. Locate the two PI boxes **(38)** & **(39)** on the shelf on either side of the Melles Griot box. These are the high-voltage power supplies that power the PZTs. Do *not* turn the power of the PI boxes until you have checked the following three things:
   - **Do not turn on the PI power supply unless you are either at atmospheric pressure or below 1×10^{-4} Torr.** At pressures in between you may get arcing in the PZTs, which can ruin them and other components of the Fabry-Perot and SPIFI.

- **Do not turn on the PI power supply unless you have turned the voltages down to 0V on channels 1, 2, and 3.** (knobs turned fully counterclockwise.) A large start-up current (voltage) could damage the PZTs, which should never receive any voltage over 700V.
- **Do not turn on the PI power supply unless the PZT cables are unplugged from the PI power supply.** This is necessary because when the PI boxes are first turned on they can output a very high voltage spike even if all the knobs are turned to 0V. Any voltage over 700V can damage the PZTs.

If the cables are unplugged, the knobs are turned to 0V, and SPIFI is below 1×10^{-4} Torr, turn on the PI box you wish to use. (We usually use the PI box on the left for the HOFPI and the box on the right for the LOFPI.) Usually the LOFPI is stable, and we only need to make regular adjustments to the HOFPI. Therefore in most cases you will only need to use the PI box on the left.

5. If channels 1, 2, and 3 are outputting 0V, connect the PZT cables to the PI box you have turned on. Connect the correct cable to the correct channel. The cables should be labeled (A ↔ 1, B ↔ 2, and C ↔ 3). Place the resistor caps which were on the cables on top of the PI power supply.
6. Carefully watch the fringes that appear on the screen hanging from the external mirror on the ADR end of SPIFI. **Slowly** turn up the three voltage knobs on the PI box (one at a time) and watch the fringes move. When adjusting the voltage knobs, **never turn the voltage of one of the PZTs above 700V. This can destroy or damage the PZT, or greatly reduce its lifetime. Keep an eye not only on the fringes but on the PI box's voltage LCD displays as well to make sure each channel is always less than 700V.** When you adjust the knob(s) in one direction the fringes should appear as straight lines and move in one direction like plane waves. When you turn the knob(s) back the other way the fringes should move in the opposite direction. At some point the fringes should rotate 90 degrees and move again in straight lines. The point at which the HOFPI and LOFPI are parallel is the point where the fringes change their motion by 90 degrees. In particular, you should see two semi-circular patterns of fringes moving towards each other and then disappearing in the middle. This is the point at which the Fabry-Perot is parallel.
7. Make a record in the SPIFI notebook that you have parallelized the HOFPI (and/or LOFPI), and record also the voltages of each channel (1, 2, and 3). This helps us compare records of past parallelizations with the current attempt, since each PZT may display individualized behavior.

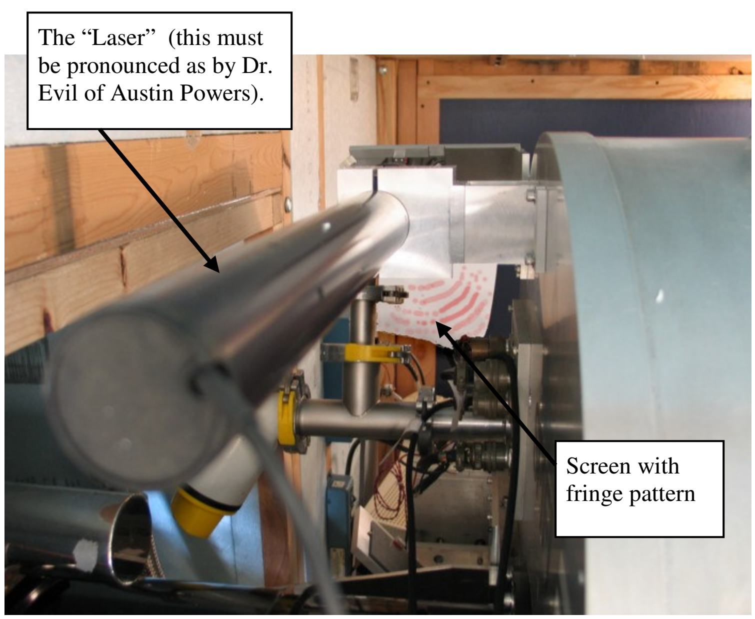
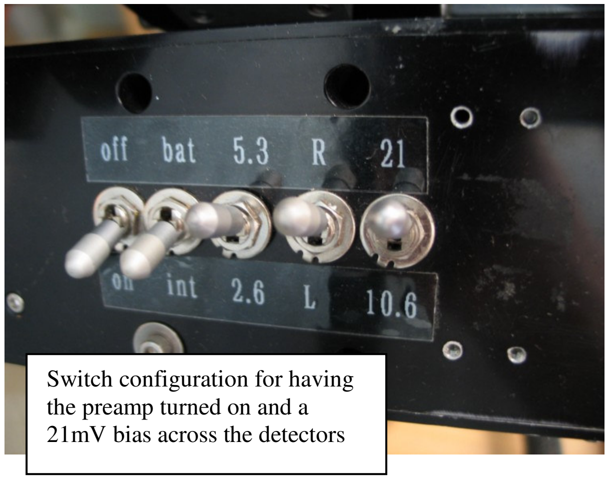


Figure 22: Parallelizing the Fabry-Perots: Observing Fringes

The Pre-Amp

The signals coming from our 25 pixel bolometer array (our detectors) must be filtered and amplified before we import them into Fabry. This is the job of the pre-amp box **(11)**, which is mounted directly to the lower left side of the ADR, as viewed when looking in the pillbox doors.

Figure 23: Preamp switches



The two grey cables with D-style connectors (with all the embarrassing packing tape wrapped around them) are our main data cables **(12)**. These are perhaps the most important cables in the whole enclosure (don't laugh). Try not to move or bump these cables too much, since they may become sensitive to noise if moved. The military style cable **(13)** on the right brings in the power supply to the pre-amp from the battery box (see *The Battery Box* on page 57 below for information on the battery box).

Table 4: Preamp Switch Positions

Desired Function of Pre-amp	Position of (leftmost) "off/on" switch	Position of "bat/int" switch	Position of "5.3/2.6" switch	Position of "R/L" switch	Position of (rightmost) "21/10.6" switch
OFF	"off" (up)	"bat" (up)	doesn't matter: switch is inactive	doesn't matter: switch is inactive	doesn't matter: switch is inactive
ON & 2.6mV bias	"on" (down)	"int" (down)	"2.6" (down)	"L" (down)	doesn't matter: switch is inactive
ON & 5.3mV bias	"on" (down)	"int" (down)	"5.3" (up)	"L" (down)	doesn't matter: switch is inactive
ON & 10.6mV bias	"on" (down)	"int" (down)	doesn't matter: switch is inactive	"R" (up)	"10.6" (down)
ON & 21mV bias	"on" (down)	"int" (down)	doesn't matter: switch is inactive	"R" (up)	"21" (up)

On the top-left-hand side of the pre-amp are five switches (pictured above). The first two (the two switches on the left-hand side, furthest in from the pillbox doors) power the preamp on and off. To turn the preamp OFF move these two switches to the "off" and "bat" positions (both switches up). To turn the preamp ON move these two switches to the "on" and "int" positions (both switches down).

The last three switches on the pre-amp (the three switches on the right-hand side, closest to the pillbox doors), labeled 5.3/2.6, R/L, and 21/10.6 are used to select the bias voltage across the detectors. The four bias voltages you can choose from are: 2.6mV, 5.3mV, 10.6mV, and 21mV. To choose either 2.6 or 5.3mV, you must have the R/L switch down on “L” (meaning the left-hand 5.3/2.6 switch is active). To choose either 10.6 or 21mV, you must have the R/L switch up on “R” (meaning that the right-hand 21/10.6 switch is active). For example, if you want a 21mV bias on the detectors, put the 12/10.6 switch up on “21”, the R/L switch up on “R”, and the 5.3/2.6 switch doesn’t matter because it is inactive (this is the configuration pictured above). All possible combinations are outlined in Table 4 above. Using a higher bias voltage can in principle result in a stronger signal and a higher signal-to-noise ratio. However, one disadvantage of using a higher bias voltage is that you can heat up the detectors and shorten the hold time of the ADR. So far 21mV has worked the best.

Any time you choose a new bias voltage setting for the pre-amp, make a note of the new setting in the SPIFI notebook.

The Battery Box

Understanding the Battery Box

To maintain low levels of noise in our data, it is necessary for the preamp **(11)** to be powered by an isolated and shielded set of batteries **(35)**. We have constructed two identical battery boxes for this purpose, with the idea that one could be used to power the preamp while the other charges, so that there is never a delay in taking data while we wait for the battery box to charge. Unfortunately, shortly before leaving South Pole Station at the end of the summer, we discovered that the second battery box (labeled #2) is defective (the military connector on the outside of the box has all the correct voltages, but when we hook it up to the preamp we get no signal, indicating that one of the batteries in the box must be incapable of putting out any power).

This is not an immediate problem, since only one battery box is needed to operate the preamp. **However, it means that you (winterovers!) will have to be diligent about putting the only battery box we have on the charger whenever you leave AST/RO for a while or whenever cycling the ADR. You will also have to be very careful to use the correct charging method, and to make sure the switches are in the correct positions when charging so that you don't damage box #1.** It should be noted that the "old" SPIFI battery box is located in the SPIFI crate labeled "A2" in the AST/RO Annex, and it should still have good batteries which can be used in an emergency.

The preamp requires a power source with DC voltages of +4V, +12V, and -12V, as well as a ground. The wiring schematic for our battery box (Figure 24 below) reveals how we accomplish this using two 12V batteries and one 4V battery.

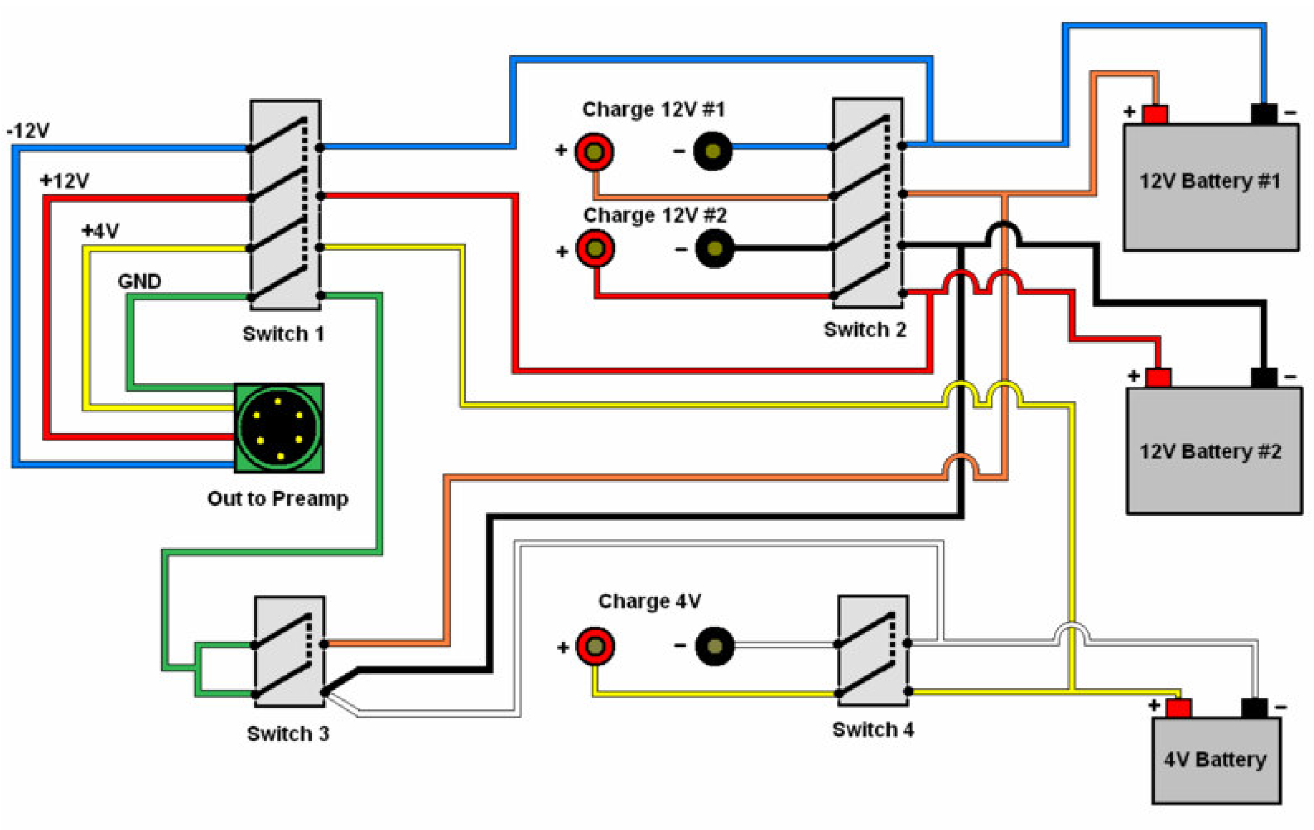
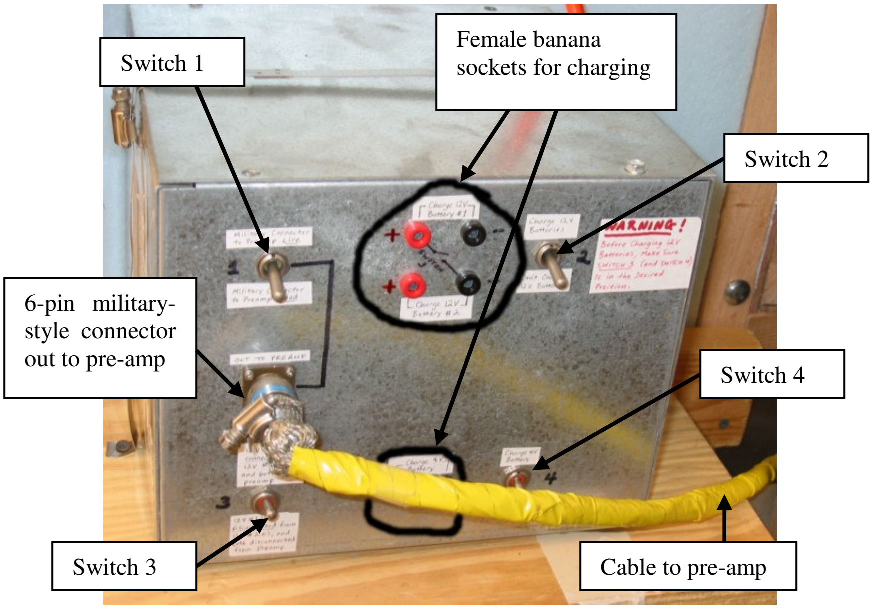


Figure 24: Battery box wiring schematic (for a single battery box)



There are some important things to take note of in the wiring schematic for the battery box. The most important by far is switch #3. **While the negative terminal of 12V battery #2 and the negative terminal of the 4V battery are always connected, when switch #3 is closed these two negative terminals are both connected with the *positive* terminal of 12V battery #1.** This is what provides the necessary -12V power source to the preamp.

Table 5: Source of Voltage for the Preamp

Voltage Out to Pre-amp	Source
+12V	positive terminal, 12V battery #2
-12V	negative terminal, 12V battery #1
+4V	positive terminal, 4V battery
floating ground	negative terminal of 12V battery #2, negative terminal of 4V battery, and positive terminal of 12V battery #1 all tied together (when switch #3 is up).

The result of the positive terminal of 12V battery #1 being connected to the negative terminals of the other two batteries is that you must take extra caution when charging, and make sure the chargers and the switches of the battery box are properly configured. The other three switches are not as important: they simply make the outputs of the battery box live or dead (on/off switches). Switch #3 changes the electrical nature of the outputs!

Table 6: Functions of Battery Box Switches

Switch	What it controls
3	connects/disconnects positive terminal of 12V battery #1 to the negative terminals of the other two batteries in the box
1	livens/deadens the output to the pre-amp
2	livens/deadens the banana plugs for 12V charging imputs
4	livens/deadens the banana plugs for 4V charging inputs

One other note: the switches we used for the battery box are 3-position switches. However, only the very top and very bottom positions have meaning (we were just trying to use up old switches in the lab). **Therefore, when you throw a switch, push it all the way up (two clicks) or all the way down (two clicks). The middle position isn't connected to anything.**

Using and Charging the Battery Box

Because we are down to only one battery box, it will need to be charged everyday while observing. Therefore, you will need to get in the habit of putting the battery box on the chargers every time you will be leaving AST/RO for a while and whenever you are cycling the ADR.

<u>Normal Use</u> (switch 1 & 3 up, switch 2 & 4 down)

Normal use is when the battery box is being used to power the pre-amp, and is not being charged (and not connected to any chargers).

1. Put switch #3 (all the way) up. This connects the positive terminal of 12V battery #1 to the negative terminals of the other two batteries, and thus provides the necessary -12V to the pre-amp.
2. Put switches #2 and #4 (all the way) down. This is just deadens the female banana sockets used for charging inputs: a safety measure.
3. With switch #1 in the down position, connect the cable to the pre-amp.
4. Put switch #1 (all the way) up. This livens the output to the pre-amp.

12V Battery Charger

<u>Normal Charging</u> (switch 1 & 3 down, switch 2 & 4 up)

Normal charging refers to the situation where the battery box is not in use (disconnected from the preamp), and is being charged with the two independent blue 12V battery chargers. **In this situation, it is imperative to have switch #3 down. This disconnects the two 12V batteries completely**, and allows them to be charged separately as normal 12V batteries would.

1. On the battery box, put switch #1 (all the way) down. This will deaden the output to the preamp. **Put switch #3 (all the way) down. This disconnects the two 12V batteries completely**, so that they can be charged independently. If the battery box was in use, switches #2 and #4 should already be down. So at this point, you should have all four switches on the front of the battery box (all the way) *down*.
2. Disconnect the cable from the pre-amp, and carry the battery box downstairs to the AST/RO annex, where the two blue 12V battery chargers are (pictured above right). There should also be a DC power supply there as well, which we used for charging the 4V battery. **Caution: all of the chargers should be *unplugged* (the two blue chargers don't have power buttons, so as soon as they are plugged in they are live!)**.
3. Now set the chargers to the appropriate charge settings.
   a) On the blue 12V chargers:
      - The SELECT SETTING switch should be set to "2A-12V AUTO"
      - The SELECT FUNCTION switch should be set to "CHARGE"
      - The SELECT BATTERY switch should be set to "NORMAL/AUTOMOTIVE"
   b) For now, turn the voltage and amperage on the small power supply all the way down to 0. You can adjust these to the appropriate values after everything is hooked up and you plug the power supply in.
4. Make sure all of the switches on the battery box are down and all of the chargers are unplugged. Each of the two blue 12V battery chargers has two male banana plug leads, one red and one black. Connect these leads

to the female banana sockets on the battery box labeled "Charge 12V Battery #1" (top center on the battery box). Make sure you connect black-to-black and red-to-red. Do the same with the second battery charger and the second set of female banana sockets on the battery box, located just below the top ones and labeled "Charge 12V Battery #2."

5. At the bottom center of the battery box you will see one more pair of red and black female banana sockets, labeled "Charge 4V Battery." Connect these to the positive and negative outputs of the small power supply via red and black banana plug cables. Make sure you connect the positive output of the power supply to the red female banana socket at the bottom of the battery box, and the negative output of the power supply to the black female banana socket at the bottom of the battery box. Note: you only need to do this if the 4V battery needs charged---it usually lasts much much longer than the 12V batteries.
6. Check to make sure all your connections make sense. If everything looks okay, plug in the two blue 12V chargers and the small power supply.
7. Turn on the power of the small power supply, and set the output voltage and current to slightly above 4V (say, 4.25V) and to 0.5A, respectively.
8. Now put switches #2 and #4 on the battery box to the up position (all the way up). This will liven all the female banana sockets on the battery box and begin the charging process.
9. When the 12V batteries are fully charged the amperage on the blue chargers will drop down close to 0A, and the "charge complete" indicator should light up (although I think the "charge complete" indicator is burned out on one of the two chargers). When the 4V battery is fully charged the amperage on the power supply will drop close to 0A.
10. When the batteries are fully charged, put switches #2 and #4 on the battery box to the down position (all the way down). This will deaden the female banana sockets on the battery box.
11. Turn the power button of the small power supply off, and unplug the power supply and both blue chargers.
12. Disconnect all of the charging leads from the battery box (make sure the chargers are all unplugged first, or these leads will be live).
13. The box is now ready for use. See *Normal Use* above.

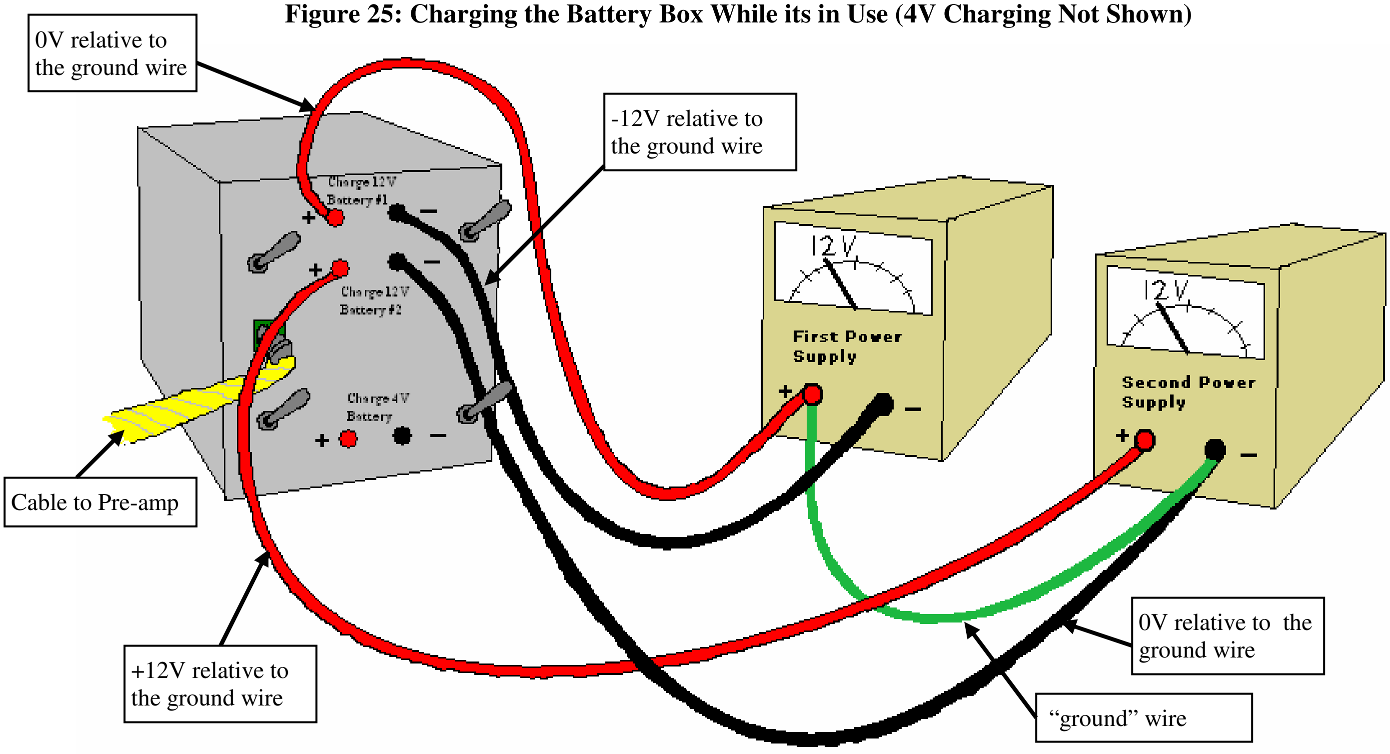
<u>Using and Charging at the Same Time</u> **(All four switches up & special charging configuration)**

The reason the battery box is so complicated is to allow the possibility of charging and observing at the same time. If both battery boxes were working, then we would probably never need to do this. However, with only one battery box, it is highly likely that we will need to observe when the battery box is in need of charging.

1. Put switch #1 (all the way) down and disconnect the cable to the pre-amp from the battery box. Keep switch #1 down and the cable to the pre-amp disconnected while you set up the chargers as a precaution against damaging the pre-amp
2. Make sure switches #2 and #4 are (all the way) down.
3. **Put switch #3 (all the way) up**. This is very important, since we will now be charging with power supplies at +12V *and* -12V.
4. Carry three power supplies up to the enclosure. (You will only need two power supplies if the 4V battery is okay. The 4V battery usually doesn't need charged nearly as often as the 12V batteries.)
5. Take two of the power supplies and connect the positive output of the first power supply to the negative output of the second power supply via a banana plug cable (this is the "ground" cable shown in Figure 25 below).
6. Plug in the two power supplies and turn on the power. Set both power supplies to 12V. Use a voltmeter to check the outputs of the two power supplies. You should observe that the negative terminal on the first power supply is outputting -12V (relative to conductor running between the two power supplies) and that the positive terminal of the second power supply is outputting +12V (relative to the conductor running between the two power supplies). See Figure 25 below.
7. You can now proceed to connect the power supplies to the battery box: connect the first power supply to the female banana sockets at the top center of the battery box labeled "Charge 12V Battery #1." Make sure you connect red-to-red and black-to-black (or + to + and - to -). Next connect the second power supply to the

female banana sockets on the battery box labeled “Charge 12V Battery #2.” Again, connect red-to-red and black-to-black (or + to + and - to -). **Make sure that the negative (black) terminal of 12V battery #1 is receiving -12V (relative to the conductor running between the two power supplies), the positive terminal of 12V battery #2 is receiving +12V (relative to the conductor running between the two power supplies), and that the other two terminals are receiving common ground (relative to the conductor running between the two power supplies)**. Refer to Figure 25 below.

Figure 25: Charging the Battery Box While its in Use (4V Charging Not Shown)



8. Turn the current output on both power supplies to 0A.
9. Put switch #2 up (all the way) on the battery box. This will liven the female banana plug sockets to which the power supplies have been connected.
10. Slowly turn up the output current on the two power supplies used to charge the 12V batteries. This will begin the charging process. You may notice that the output voltage on the power supplies is a function of the output current. For instance, when the power supply output current is set to the usual 2A used for peak charging, the output voltage may read lower than 12V. You may want to check the output voltages of the battery box at the military style connector which connects to the prep-amp, and see if it reads +12V, -12V, and 4V, (on the top left, top center, and top right pins) relative to ground (which is the bottom center pin). You may find that you need to turn up the amperage a bit higher to get closer to 12V. This seems to be okay for a while, but when the batteries become partially charged you may want to turn down the amps.
11. If you also need to charge the 4V battery (which doesn’t need done as often), hook up a third power supply and connect it to the battery box as described in steps 5 and 7 under *Normal Charging* on page 60 above. Depending on how depleted the 4V battery is, you may need to turn up the current a little to keep the output voltage just above 4V. Also, you will need to put switch #4 (all the way) up on the battery box.
12. Once everything is set up okay, connect the pre-amp cable to the battery box and flip switch #1 to the up position (all the way). You should now have all four switches on the battery box up (all the way).
13. Now turn on the pre-amp (see *The Pre-Amp* on page 55) and take a scan to see if you get a signal (refer to the SPIFI Data Acquistion manual).

PART 3: WARM UP PROCEDURE

Whenever SPIFI operations are complete, use the procedure outlined here to safely warm SPIFI up to room temperature and shut everything down:

1. Backfill the ADR's l-^{4}He tank with ^{4}He gas and open it to the atmosphere (use steps 1-6 in the *ADR Helium* subsection under *Maintenance Filling* on page 35 above). It is very important to do this, **or else you could get an overpressure in the ADR's l-^{4}He tank** as the l-^{4}He boils off.
2. Backfill SPIFI's l-N_2 tank with N_2 gas and open the tank to the atmosphere (you may want to refer to Figure 12 on page 34 above):
   - □ In the receiver room, open the N_2 gas cylinder (make sure you don't accidentally hook up the ^{4}He gas) and adjust the regulator so that about 2 psi are going to the roof through the clear Teflon tube.
   - □ Close the main brass vacuum valve on the SPIFI nitrogen neck **(30)**.
   - □ Disconnect the pumpzilla vacuum hose from the brass valve on the SPIFI nitrogen neck (but only if the brass valve is closed!).
   - □ Attach the Teflon tube with the N_2 gas supply to the brass valve on the nitrogen neck where the vacuum hose used to be attached via a yellow latex hose. You will need to rig some adaptor here.
   - □ Let SPIFI suck on the N_2 gas as it warms up. This process can take a very very long time (several hours). The reason it takes so long is that the N_2 in the tank is solid. Therefore the N_2 gas going in immediately becomes liquid and the pressure drops very low (and everything stays cold).
   - □ **At some point when all of the N_2 is liquid, SPIFI will stop sucking and you will get a sudden large boil-off and an overpressure can quickly develop, so be ready to remove the hose when SPIFI stops sucking! (Don't leave AST/RO).** To check if SPIFI is still sucking, use one of the following two methods:
     - (a) Pinch off the yellow latex hose and let N_2 gas build up on one side of the pinch. Then pinch the hose at a second position on the N_2 gas side of your first pinch so that you have trapped N_2 gas between your two pinches. Then remove your first pinch and see if the hose collapses where you had trapped the N_2 gas. If it collapses, SPIFI is still sucking. If it doesn't collapse, SPIFI is done.
     - (b) Another alternative way to check if SPIFI is still sucking is to reclamp (or pinch) the yellow latex hose, remove the Teflon tube with the N_2 gas supply, place your thumb over the end of the yellow latex hose, and briefly open the clamp (or release your pinch) and see if you feel a suction on your thumb. If you do feel a suction, quickly close off the hose again and reattach the N_2 gas. **Don't let the l-N_2 tank suck on the atmosphere for very long while you are doing this test or you could get an ice plug in the l-N_2 neck!**
   - □ Once SPIFI is done sucking you can remove the N_2 gas supply and leave the l-N_2 tank open to the atmosphere. The l-N_2 in the tank will boil off in time. You may want to remove the special stinger assembly from the l-N_2 neck and check that the l-N_2 is still boiling off (hold your thumb over the neck's vent for a little while, release, and see if you see a plume). If there doesn't seem to be any boil-off coming from SPIFI's l-N_2 neck, drop a copper rod down the neck to make sure you don't have an ice plug.

   It is very important to backfill the SPIFI l-N_2 tank and open it to the atmosphere, **or else you could get an overpressure in SPIFI's l-N_2 tank** as the l-N_2 boils off.
3. Leave the main pump valve **(55)** on SPIFI closed. You can leave SPIFI under vacuum and let it slowly rise in pressure on its own before summer 04-05. I.e., leave SPIFI hooked up to the turbo pump and leave everything alone.
4. Turn off all the pumps if they aren't off already:
   - □ The turbo pump **(51)** can be turned off by pushing the button on the front once.
   - □ The gas cell pump **(41)** can be turned off by unplugging it.
   - □ The two "pumpzillas"in the receiver room can be turned off by flipping off the switches on the breaker boxes on the wall.
5. Properly shutdown Fabry **(50)**:

- □ Turn on the monitor inside the right side door of the enclosure
- □ At the prompt, type the following sequence of commands (“>” means type at the prompt, “␣” means hit the space bar once, and “↵” means strike the enter key):

  - > root ↵
  - > whoami ↵

  This last command, “whoami”, will tell you what kind of user you are. If you are the “root” user, continue. If you are not “root”, type > su ↵ and enter the password > r = fin*ord ↵ to become the super user. Then continue:

  - > cd ␣ / ↵
  - > shutdown ␣ -h ␣ now ↵

- □ Wait for Fabry to go through its shutdown procedure.
- □ When the screen indicates that everything has been halted, go ahead and push the power buttons on the Fabry PC and on the monitor.

6. Shutdown the PZT’s:

   HOFPI
   - □ Turn the PZT voltages all the way down (fully counterclockwise) on the PI power supply **(38)**. Make sure channels 1, 2, and 3 are all at 0V.
   - □ Diconnect all three PZT cables (A, B, & C) from the PI power supply and cap them with the resistor caps which should be on top of the PI power supply.
   - □ Turn off the PI power supply.

   LOFPI (If applicable: We did not need to use the LOFPI PZT’s over the Antarctic summer)
   - □ Turn the PZT voltages all the way down (fully counterclockwise) on the PI power supply **(39)**. Make sure channels 1, 2, and 3 are all at 0V.
   - □ Diconnect all three PZT cables (A, B, & C) from the PI power supply and cap them with the resistor caps which should be on top of the PI power supply.
   - □ Turn off the PI power supply.

7. Shut down all other electronic devices:

   - □ Calibration control box **(46)**: in the following order (and from right to left), turn off the temperature control unit, turn off the driver, turn off the indexer, turn off the main power switch.
   - □ Turn off the resistance bridge box **(47)**.
   - □ Cryo-motor box **(48)**: in the following order, turn off both the HOFPI and LOFPI driver power, turn off the indexers’ power, and turn off the main power.
   - □ SPIFI motor box **(49)**: in the following order, turn off switch “5,” and then turn off the main power.
   - □ Make sure the “laser” power is turned off **(37)**.
   - □ Turn off the battery box **(35)** by pushing Switch #1 on the battery box down.
   - □ Turn off the preamp **(11)** by moving the two left-most switches to “off” and “bat” (both switches up).
   - □ Make sure the magnet control box and magnet power supply are turned off **(22)** & **(23)**.
   - □ Make sure the the charcoal heater (small green power supply) is turned off **(25)**.
8. Check around the enclosure one last time to make sure everything is turned off.
9. **Leave the heaters in the enclosure running and make sure all the doors and hatches in the enclosure are shut and latched!**

DONE!

Appendix A

Table 7: Height vs. Volume for SPIFI Cryo-Tanks

SPIFI I-^{4}He Tank			
Height (in)	Volume (L)	Height (cm)	Volume (L)
0.25	1.9	0.5	1.5
0.50	3.8	1.0	3.0
0.75	5.7	1.5	4.5
1.00	7.5	2.0	5.9
1.25	9.4	2.5	7.4
1.50	11.3	3.0	8.9
1.75	13.1	3.5	10.3
2.00	14.9	4.0	11.8
2.25	16.8	4.5	13.3
2.50	18.6	5.0	14.7
2.75	20.4	5.5	16.2
3.00	22.2	6.0	17.6
3.25	24.0	6.5	19.0
3.50	25.8	7.0	20.4
3.75	27.5	7.5	21.9
4.00	29.3	8.0	23.3
4.25	31.0	8.5	24.7
4.50	32.7	9.0	26.1
4.75	34.4	9.5	27.4
5.00	36.0	10.0	28.8
5.25	37.7	10.5	30.2
5.50	39.3	11.0	31.5
5.75	40.9	11.5	32.9
6.00	42.5	12.0	34.2
6.25	44.0	12.5	35.5
6.50	45.5	13.0	36.8
6.75	47.0	13.5	38.1
7.00	48.5	14.0	39.4
7.25	49.9	14.5	40.6
7.50	51.3	15.0	41.9
7.75	52.7	15.5	43.1
8.00	54.0	16.0	44.3
8.25	55.3	16.5	45.5
8.50	56.5	17.0	46.7
8.75	57.7	17.5	47.9
9.00	58.9	18.0	49.0
9.25	60.0	18.5	50.1
9.50	61.0	19.0	51.2
9.75	62.0	19.5	52.3
10.00	62.9	20.0	53.3
10.25	63.8	20.5	54.4
10.50	64.6	21.0	55.4
10.75	65.3	21.5	56.4
11.00	65.8	22.0	57.3
		22.5	58.2
		23.0	59.1
		23.5	60.0
		24.0	60.8
		24.5	61.6
		25.0	62.4
		25.5	63.1
		26.0	63.7
		26.5	64.4
		27.0	64.9
		27.5	65.4
		28.0	65.9

SPIFI I-N_2 Tank			
Height (in)	Volume (L)	Height (cm)	Volume (L)
0.25	0.7	0.5	0.6
0.50	1.5	1.0	1.2
0.75	2.2	1.5	1.7
1.00	2.9	2.0	2.3
1.25	3.6	2.5	2.9
1.50	4.4	3.0	3.4
1.75	5.1	3.5	4.0
2.00	5.8	4.0	4.6
2.25	6.5	4.5	5.1
2.50	7.2	5.0	5.7
2.75	7.9	5.5	6.3
3.00	8.6	6.0	6.8
3.25	9.3	6.5	7.4
3.50	10.0	7.0	7.9
3.75	10.7	7.5	8.5
4.00	11.4	8.0	9.0
4.25	12.0	8.5	9.6
4.50	12.7	9.0	10.1
4.75	13.3	9.5	10.7
5.00	14.0	10.0	11.2
5.25	14.6	10.5	11.7
5.50	15.3	11.0	12.2
5.75	15.9	11.5	12.8
6.00	16.5	12.0	13.3
6.25	17.1	12.5	13.8
6.50	17.7	13.0	14.3
6.75	18.3	13.5	14.8
7.00	18.8	14.0	15.3
7.25	19.4	14.5	15.8
7.50	19.9	15.0	16.3
7.75	20.5	15.5	16.7
8.00	21.0	16.0	17.2
8.25	21.5	16.5	17.7
8.50	22.0	17.0	18.1
8.75	22.4	17.5	18.6
9.00	22.9	18.0	19.0
9.25	23.3	18.5	19.5
9.50	23.7	19.0	19.9
9.75	24.1	19.5	20.3
10.00	24.4	20.0	20.7
10.25	24.8	20.5	21.1
10.50	25.1	21.0	21.5
10.75	25.3	21.5	21.9
11.00	25.6	22.0	22.3
		22.5	22.6
		23.0	23.0
		23.5	23.3
		24.0	23.6
		24.5	23.9
		25.0	24.2
		25.5	24.5
		26.0	24.8
		26.5	25.0
		27.0	25.2
		27.5	25.4
		28.0	25.6